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Cables :: "Stomata." | Phone :: 2183

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AGRICULTURE AND INDUSTRY.

IN his Mather* lecture to the Textile Institute, Sir Harold Hartley asked: "To what extent is agriculture likely in the future to supply the raw materials for industry in addition to food and textiles, her main customers to-day"? According to him the answer to this question involves a forecast of both demand and supply: whether the nature of the demands will alter, and whether in meeting them materials or manufacturing methods will change fundamentally. Biochemistry and biotechnology are of great significance for the future of industry, but their value will be judged largely by their power to save expenditure of material and energy. For more than a century, organic chemists have been investigating the atomic structure of the products of organic life, and the new weapons, X-rays and electron diffraction, have been of great service. We still know, however, very little of the mechanism used by Nature in synthesizing these complex substances although it is clear that they are built up on comparatively simple models. The chemist, by elucidating their structure, has succeeded in synthesizing many of them artificially but, in spite of his triumphs, Nature has proved to be a cheaper producer than the factory, and is likely to remain so.

The use of cracked oil gas and natural gas in the United States as starting-points for the manufacture of organic chemicals, and also their production from water gas by catalytic processes, and from calcium carbide made in the electric furnace, has threatened to displace the use of plant products. Here there is direct competition with the products of the fermentation industry and of wood distillation. Synthetic 'rubber' made from cracked oil gas is another example of this competition. On the other hand, the more detailed knowledge of plant products has led to great developments in their extraction and utilization, for example, the process of fat-hardening, the conversion of molasses into alcohol, glycerin, acetone and other solvents, and the production of furfural from cereal wastes for use as a solvent or as a constituent of plastics. Research has also opened up completely new fields, such as the cellulose products and synthetic resins or plastics, in which agricultural materials like casein, glycerin, soya bean are finding fresh outlets. The possibilities of plastics are great but at present they are handicapped by high cost.

* *Nature* Vol. CXL, No. 3536; pp. 221-222, 1937.

At present roughly 12 per cent., by value, of the world's agricultural production is used for industrial purposes but the proportion is raised to one-third if forest products are included. The extent to which agricultural materials may replace minerals and metals will depend on physical properties and cost. Some plastics are suitable for replacing metals; the use of synthetic resins as adhesives, and the improvements in the manufacture of laminated wood already make it a successful rival to metal in many fields, for the new products possess such advantages as absence of fatigue, high ratio of strength to weight and resistance to corrosion, whilst the defects of wood due to local weakness are eliminated by the laminated structure. Rubber is also supplanting metal in fields where its elasticity, freedom from abrasion, and value in reducing noise are required. Laminated wood is finding many applications in building construction owing to its strength, lightness and low cost; and the substitution of nitrocellulose and synthetic resins for the older natural resins, and that of the new solvents and plasticizers for the older and cruder materials of the forest-produced type, all in the main involve the use of processed agricultural products. The costs of producing fermentation alcohol from molasses and from maize are higher than that of producing petrol; its use today as motor fuel is only justifiable on strategic grounds, but when petroleum supplies begin to contract, alcohol will be in a better competitive position. There has been a very great development in the use of new packing materials, made of wood, textiles, cellulose, cellophane, &c., but mineral oils have been replacing vegetable oils for lubrication, although the total consumption of the latter has not declined.

In the United States the Farm Chemurgic Council, in association with the Department of Agriculture, is working strenuously to promote the use of American farm products by finding new outlets for established crops, by finding new crops like soya bean, tung oil and southern pine, to replace products now imported, and by better utilization of agricultural waste. The soya bean, especially, has been found to be a particularly valuable crop and substances extracted or made from it have manifold uses. The oil is used in edible products and in making paints, enamels, varnishes, linoleum, soap and printing ink. The meal is mainly used in foodstuffs, but a good deal goes also to the manufacture of protein glues, paper sizes, washable wall-papers and protein plastics.

Among new outlets for old crops are the use of cotton fabric for reinforcing tarred roads, of inferior cotton and cotton linters for making cellulose derivatives, and of maize for the production of starch, dextrin, corn syrup, dextrose, corn oil and cake. Also under investigation is the utilization of the enormous quantities of straw, cotton stalks, and husks that now run to waste. In California cull citrus fruits are being processed for producing citric acid, citrus oils and pectin. Finally, sugar or starch derived from second-grade maize or other grain, sugar beet, and molasses is being converted into industrial solvents.

It will be evident that considerable energy and skill are being devoted to discovering new uses for many agricultural products in the field of industry. Although much progress has already been made in this direction the possibilities for further expansion are not in any way exhausted. If the use of carbon compounds is being extended at the present rate and we are approaching what Sir Harold Hartley describes as a cellulose plastic age, large quantities of cellulose will be required which will have to be supplied by plants. In this respect the tropics should provide a particularly fertile source of the raw materials needed. So far, a few major crops such as cotton, maize and sugar cane have provided suitable raw materials for industrial purposes but there must be many other tropical plants whose uses might be studied with the same object in view. It is hoped, therefore, that more attention will be paid to this problem than has been done hitherto as it offers not only a promising field for research but also may reveal new outlets for the profitable disposal of tropical crop products.

FOWL-POX AND ITS TRANSMISSION.

Fowl-pox is a virus disease which attacks chickens, pigeons, geese, turkeys and other birds, and causes considerable loss to the poultry farmer. It appears as cheesy diphtheritic membranes in the mouth, and as warty growths on the comb, wattles and mucous membrane of the mouth and eyelid. In the past, it was supposed that these various lesions were caused by different agents, but R. L. Kaura and S. G. Iyer confirm the present view that all are due to a single filter-passing virus (*Indian J. Vet. Sci. and Animal Husbandry*, 6, Pt. iv, 313, 1936). They find that diphtheritic lesions from the mouth produce the fowl-pox lesions on the skin, and that the Indian strain of virus is immunologically indistinguishable from the English Weybridge strain. A. L. Brody has studied the transmission of the disease (*Cornel Univ. Agric. Expt. Station, Memoir* 195 Ithaca, N.Y., 1936). Direct contact is one certain method by which fowl-pox is spread within a flock, and contaminated inanimate objects may possibly do so as the virus of them remains alive for at least six weeks. Mosquitoes, such as *Aedes aegypti*, may also transmit the contagion by intermittent feeding. Inoculation of the bodies of mites (*L. sylviarum*) four days after their last association with diseased birds produced pox, but mites after feeding on diseased, and then on healthy, birds did not cause pox.—(*Nature*, Vol. 139, No. 3525, p. 889, 1937.)

BANANA DISEASES.

XI.—Notes on Some Plantation Diseases in Guadeloupe.

By C. W. Wardlaw.

In the Island of Guadeloupe (French Antilles), the banana of commerce is the Congo or Poyo, a mutant of intermediate stature belonging to the Cavendish group. Occasional plants of the Gros Michel, Dwarf Cavendish and other varieties occur throughout the plantations. The diseases, briefly annotated below, were observed.

Panama Disease.

This wilt disease, caused by *Fusarium oxysporum cubense*, was observed on the Gros Michel. In some areas extensive wilting has been reported, but as Gros Michel fruit is not at a premium on French markets, the disease is not regarded as economically important. Where necessary, eradication of diseased stools by the gas oil treatment should be carried out (7).

Bacterial Wilt Disease.

Occasional attacks of this disease, also commonly known as Moko disease (*Bacterium solanacearum* E.F. Sm.), occur on the Congo variety, causing a discoloration, wilting and dropping of leaves just when the bunch is filling out. Destruction of infected stools by the gas oil treatment is recommended. Stehlé (6) has suggested remedial measures adapted to local requirements.

Virus and Heart-Rot Disease.

On a localised hillside area, planted with the Congo variety (the planting materials possibly having all been derived from one source) a complex form of disease, comprising both virus markings on the leaves, and an extensive type of heart-rot of the youngest unrolled leaf and of the inner tissues of the pseudostem, was observed in some detail. The leaf markings, in the form of a characteristic mottling, consist of light chlorotic linear areas, extending as irregular broken, sometimes coalescing stripes, from midrib to margin; these chlorotic areas are whitish or pale yellow in young leaves, but on older leaves they acquire yellowish, brownish-red and finally bluish-black hues. In some leaves mosaic symptoms may be present over the entire surface: in others, only localised bands, isolated spots or marginal areas may be present. Leaf symptoms of this type have already been observed in Brazil, Trinidad and Bermuda (7). The striking feature of the Guadeloupe disease is the association of a severe heart-rot condition. In early stages, only the tip of the youngest unrolled leaf may be rotted and blackened. Later, the whole leaf becomes blackened, and evidence of further rotting, in the form of brownish (?bacterial or fungal) cavities, is to be observed in the surrounding leaf sheaths. From the crown of the plant, the heart rotting, in the form of wet, brownish cavities in the open tissue of the leaf sheaths, progresses downwards until the compact tissue of the rhizome is reached. At this point a sharp line of demarcation separates healthy and infected tissue. In general, it may be said that the heart-rot symptoms are well defined and characteristic. Occasionally, young sword suckers of affected plants may be observed in a rotted and shrivelled condition. So far as the present writer is aware, no exactly comparable heart-rot of bananas, associated with a virus mottling of the leaves, has hitherto been recorded in the Caribbean region.

In 1930 Magee (2) reported what was apparently a new and important disease of bananas in New South Wales. It was characterised by mottling or streaking of the leaves, rotting of leaf margins, the assumption of a rigid erect habit, and a rotting of the heart-leaf and central portion of the pseudostem. To this Australian disease the name of Heart-Rot or Infectious Chlorosis has been applied (2, 3). The heart-rot stage, under Australian conditions, apparently occurs only during the winter months, but the leaf symptoms may appear throughout the year. It is to be noted that the severe infection described above for Guadeloupe bananas came under observation at the end of the dry and beginning of the wet season. Some abnormal leaf conditions were also observed but in the course of a short visit it could not be determined whether these were in the nature of pathological symptoms or merely the result of renewal of growth with the advent of the rains. From the evidence submitted, the strong similarity between the Australian and Guadeloupe diseases cannot be overlooked: further investigation may prove that they are identical, minor differences in symptoms being associated with environmental conditions. An early account of a type of heart-leaf disease, described by Ashby (1) in Jamaica, has several points of similarity with the disease under consideration.

Heart-rot or infectious chlorosis has now been proclaimed a disease under the New South Wales Plant Diseases Act (8); control measures are based on those used in combating Bunchy Top (4). The disease is distinct from the latter virus disease, but Magee (2) considers that if it were to become widespread, it would be a serious menace to the banana industry. The severity of the disease as observed in one localised area in Guadeloupe by the present writer would appear to lend support to this opinion. Accordingly the disease should be carefully surveyed and all infected stools killed *in situ* by the gas oil treatment. In Australia the virus is transmitted by the banana aphis, *Pentalonia nigronervosa*.

Cercospora Leaf Spot.

Leaf spotting, caused by *Cercospora musae* Zimm., occurs in several areas as a light, general infection on the Congo banana. So far, the extent of infection is not sufficient to cause a reduction in the output of fruit. The progress of this disease should be kept under close observation.

Cordana Leaf Spot.

Large brown blotches or spots, caused by the weakly parasite fungus *Cordana musae* (Zimm.) Höhn., are occasionally present on old leaves or on leaves torn by the wind. This disease is unimportant.

Leaf Speckle.

A slight leaf speckling or mottling, ascribed by Stahel (5) to *Chloridium Musae* Stahel, is of not infrequent occurrence in some areas. This disease is also unimportant.

Black-Tip Disease.

A disease of green fruits, characterised by a blackening of the distal end or tip, and caused by the fungus *Helminthosporium torulosum* (Syd.) Ashby, was occasionally observed in plants of the Congo variety which were making slow growth in an area of low-lying, compact silt, subject to inundation. These are the conditions already known to favour this disease, which is of minor importance.

Thrips Injury.

In plantations where *Canavalia ensiformis* (sword bean) has been cultivated between the banana rows as a cover crop, a considerable amount of spotting, attributed to a species of thrips, *Frankliniella insularis*, is present on the bunches. Recent investigations (9) have shown that this thrips species, commonly associated with leguminous plants in the West Indies, leaves its normal host and lays its eggs in the epidermis of very young banana fruits growing in proximity. From the evidence available, the eradication of the cover crop prior to the shooting of bunches affords a simple and direct means of reducing this type of spotting.

Borer Injury.

Evidence of borer (*Cosmopolites sordidus*) injury was observed in various plantations, particularly where soil conditions had been conducive to slow growth. The presence of borers in the rhizome is usually indicated by the appearance of dull yellow bands on the leaves, running from mid-rib to margin; the distal end of certain leaves may also assume a yellowish discoloration, later becoming brown and assuming a characteristic curvature. Where soil conditions were favaourable and growth active, the effect of borer injury was negligible.

References.

1. Ashby, S. F.—Banana Diseases in Jamaica. *Bul. Dept. Agr. Jamaica*, s. 2, II, 1913.
2. Magee, C. J.—A New Virus Disease of Bananas. *Agr. Gaz. New South Wales*, XLI, 12, 1930.
3. Morwood, R. B.—The Work of the Pathological Branch. *Ann. Rept. Queensland Dept. Agr. and Stock for the year* 1930-31, pp. 47-48, 1931.
4. Simmonds, J. H.—The Work of the Pathological Branch. *Ann. Rept. Queensland Dept. Agr. and Stock for the year* 1931-32, pp. 56-57, 1922.
5. Stahel, G.—The Banana Leaf Speckle in Surinam caused by *Chloridium Musae* Nov. Spec. and another Related Banana Disease. *Tropical Agriculture*, XIV, 2, 1937.
6. Stehlé, H.: Sur une maladie des Bananiers a la Guadeloupe. *Rev. Agric. Guadeloupe*, VIII, 9 & 10, 1936.
7. Wardlaw, C. W.—Diseases of the Banana. *Macmillan & Co., London*, 1935.
8. Bananas in New South Wales. *Fruit World of Australasia*, XXXII, 9, 1931. (Heart Rot proclaimed a Disease under the New South Wales Plants' Diseases Act, 1924.)
9. West Indian Notes.—*Tropical Agriculture*, XIV, 7, 1937.

A NOTE ON TWO LARVAL PARASITES OF THE SUGAR-CANE MOTH-BORER IN SAO PAULO, BRAZIL

By Sydney Cross Harland, D.Sc. (Lond.).

In view of the fact that the various species of Diatraea (Sugar-cane moth-borer) cause much damage to sugar cane in Barbados, British Guiana and other parts of the West Indies any new records of parasites become of considerable interest. Specimens of two species of Diatraea parasites have been reared in the writer's laboratory from material collected by Mr. Pedro Texeira Mendes in Piracicaba, State of Sao Paulo. Specimens were submitted to Dr. C. H. T. Townsend and he states that one of the species is *Metagonistylum minense* TT. and the other *Paratheresia brasiliensis* TT. The former species was present in great abundance, approximately 56 per cent. of the larvae being attacked. 2,000 Canes were cut open, 187 Diatraea larvae found and 105 pupae of larval parasites. The majority of these were of the former species. A large number of the parasite pupae were attacked by a hyper-parasite still unidentified.

Metagonistylum minense TT. is of course the well known Amazon fly recently introduced by Myers into the West Indies. The Sao Paulo form differs from the usual type in being a melanic variant and since it occurs in regions characterised by a very long dry season and considerably less rainfall than that of the Amazon form it is probable that we have here a different biological race which may prove more adapted to conditions in certain of the West Indian Islands than those introduced from the Amazon. In the writer's view it is of extreme importance in parasite work to introduce a promising parasite from all parts of its geographical range, since success may result from a form with a severely restricted geographical distribution. A further possibility is that forms from two ecologically distinct areas may cross and give rise to new forms of parasite with a wide range of adaptability.

THE PHYSICAL ENVIRONMENT, FAUNA AND AGRICULTURE OF THE BRITISH SOLOMON ISLANDS.

By R. J. A. W. Lever, B.Sc., Hon. (Dunelm.), D.I.C. (Lond.), A.I.C.T.A. (Trinidad), F.L.S., F.R.E.S.

A Previous article in *Tropical Agriculture* (1) gave a general account of this double chain of islands with notes on some of their insect pests. A more detailed description, with particulars of research since 1932, is given in the following article, which lists many references not cited in the earlier one.

Geology.

A general sketch of the geology was given by Guppy (2) as long ago as 1887, but details were more or less restricted to the western (Shortlands) and eastern (San Cristobal) ends. Descriptions of specimens from other islands followed by Watts and Newton (3) and these two sources furnished the account given by Reed (4).

The longest islands (Malaita and Isabel) are about 110 miles in length, with an area of some 1,600 to 1,700 square miles; the largest (Guadalcanal) covers 2,500 square miles, equal to that of the West Riding of Yorkshire. These and most of the other large islands are composed chiefly of such igneous rocks as dolerite, diorite, quartz-diorite, biotite-granite and gabbro with serpentine, and are believed to be of Cretaceous age. Kolombangara and New Georgia are, however, chiefly of such volcanics as pyroxene-augite-hornblende-and hypersthene-andesites with olivine-basalt. Overlying the first-mentioned igneous rocks in the east are volcanic tuffs and andesites of early Tertiary age. The remote Santa Cruz Islands were found, from specimens sent by the author to Mr. Campbell Smith of the British Museum, to be of porphyritic olivine-basalt, that from Utupua Island being rather vesicular.

Some of the smaller islands, such as Ugi and Ganonga, are of pteropod or foraminiferal deposits, and their gently rounded profile is in marked contrast to the more or less serrated outline of the larger igneous islands. Some of the most fertile islands in the Protectorate are the Russell Islands (Banika and Pavuvu), with a basalt core overlaid with coral limestone which weathers into an excellent soil. Such calcareous deposits are rarely found at a greater height than 500 to 600 feet (2) owing to the extensive sub-aerial denudation.

The Solomon Islands lie in an area of elevation, proof of which can be found in the distinct coral-terraces at various heights. In 1882 Guppy cut a mark in a cliff on Ugi at a point 6½ feet above mean sea level; this spot was located by the writer in 1935 (5) and found to be now 7½ feet above half tide, thus showing a rise of about a foot in half a century.

Two atolls occupy isolated positions, one (Liueniua or Ontong Java) being 115 miles north of Isabel and the other (Sikaiana or Stewart Island) 125 miles east of Malaita. They are both inhabited by Polynesians whose ancestors, at least in the case of Sikaiana, came from the direction of Samoa.

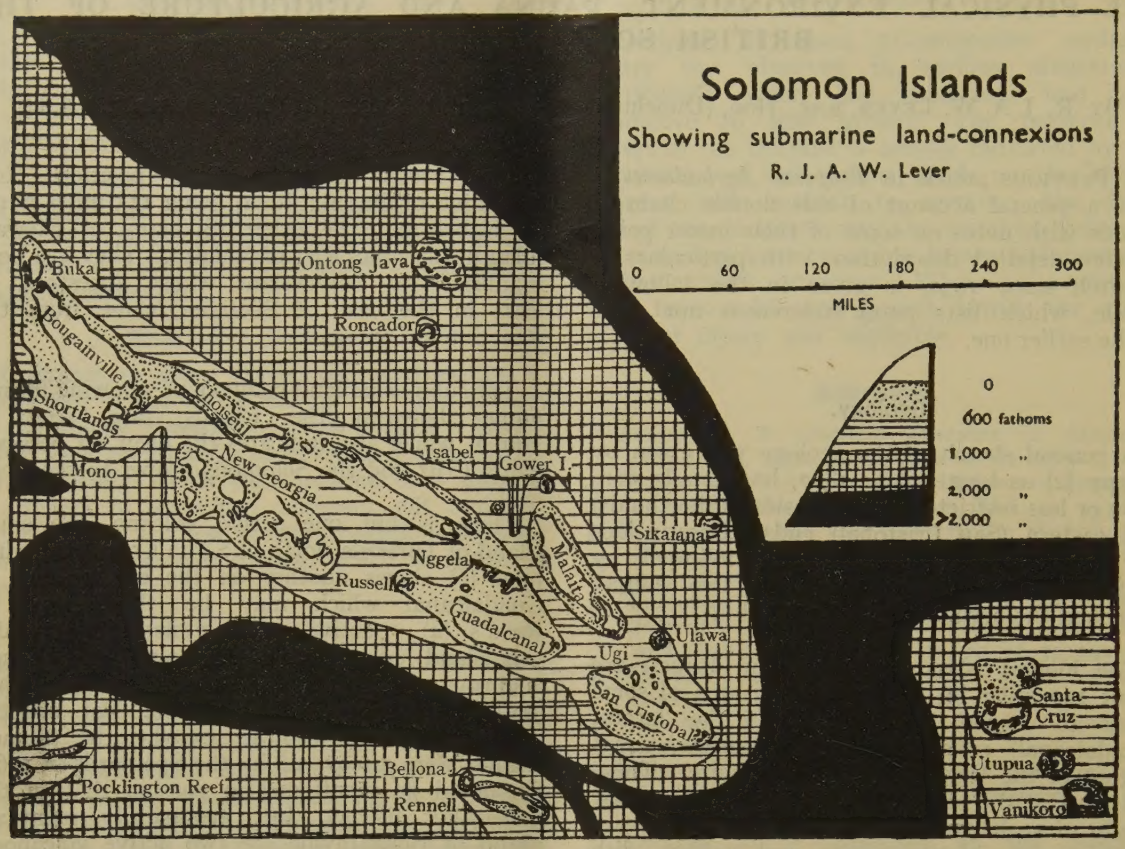
The submarine land-connexions, showing former union between the islands, are seen in Map 1, which also indicates the deep sea between Santa Cruz and the Solomons proper to the west.

There is but one active volcano—the small island of Tinakula north of Santa Cruz. Darwin's map (6) shows another on the eastern end of Guadalcanal which may be the source of Reed's (4) "active volcanic zones". Actually this island has not even a single volcano, though a dormant one occurs on Savo. This island has andesite and andesitic tuff and last erupted about 1845, as was also the case when the Solomon Islands were discovered by the Spaniards in 1568. It should be mentioned in passing that in the politically distinct, but geologically identical, island of Bougainville are two active volcanoes. Within the Protectorate, however, the only other signs of subterranean forces at the present day are boiling sulphur springs on Guadalcanal and Savo and similar fumaroles on Vella Lavella and Simbo or Narovo. The hot spring on Guadalcanal is believed by the natives to be of therapeutic value for ulcers; it lies some 10 miles inland from Tasavaronga and a sample of the water was found by the author to have a reaction of pH 7.4.

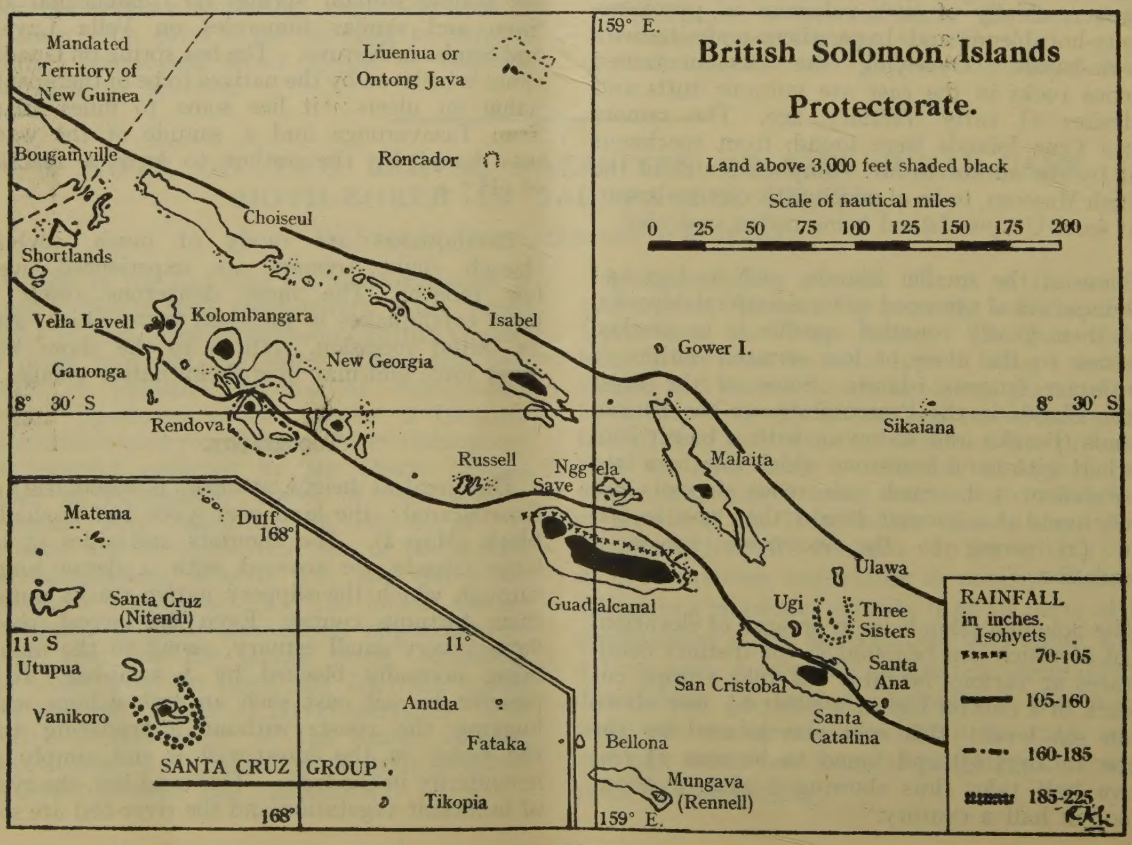
Earthquakes are rarely of much severity though slight tremors are experienced every few months. The most dangerous result of large earthquakes is the tidal wave which, after an initial recession, returns to the shore with great force and may overwhelm native villages.

Topography.

The greatest height attained is 8,000 feet, on Guadalcanal; the land over 3,000 feet is shaded black (Map 2). The summits and sides of the large islands are covered with a dense jungle through which the slippery native tracks pursue their tortuous course. Even the largest rivers have a very small estuary, owing to the mouth being normally blocked by a sand-bar. It is possible to sail past such an embouchure while hugging the coast, without appreciating that the break in the forest-wall is not simply an irregularity in the trees. This sand-bar, the types of luxuriant vegetation and the river-bed are seen


Solomon Islands
Showing submarine land-connexions
R. J. A. W. Lever
0 60 120 180 240 300
MILES
0
600 fathoms
1,000 ,,
2,000 ,,
>2,000 ,,
Buka
Ontong Java
Roncador
Bougainville
Shortlands
Choiseul
Mono
New Georgia
Isabel
Gower I.
Sikaiana
Nggela
Russell
Malaita
Guadalcanal
Ulawa
Ugi
San Cristobal
Santa Cruz
Utupua
Vanikoro
Bellona
Rennell
Pocklington Reef

MAP 1.


Mandated Territory of New Guinea
Liueniua or Ontong Java
159° E.
British Solomon Islands Protectorate.
Land above 3,000 feet shaded black
Scale of nautical miles
0 25 50 75 100 125 150 175 200
Bougainville
Roncador
Choiseul
Shortlands
Vella Lavell
Kolombangara
Isabel
Gower I.
Ganonga
New Georgia
8° 30′ S
Rendova
Sikaiana
Russell
Nggela
Save
Malaita
Matema
Duff
168°
Ulawa
Santa Cruz (Nitendi)
Guadalcanal
Ugi
Three Sisters
11° S
11°
Utupua
Santa Ana
San Cristobal
Vanikoro
Anuda
Santa Catalina
Fataka
Bellona
SANTA CRUZ GROUP
Mungava (Rennell)
Tikopia
168°
159° E.
RAINFALL in inches.
Isohyets
70-105
105-160
160-185
185-225

MAP 2.

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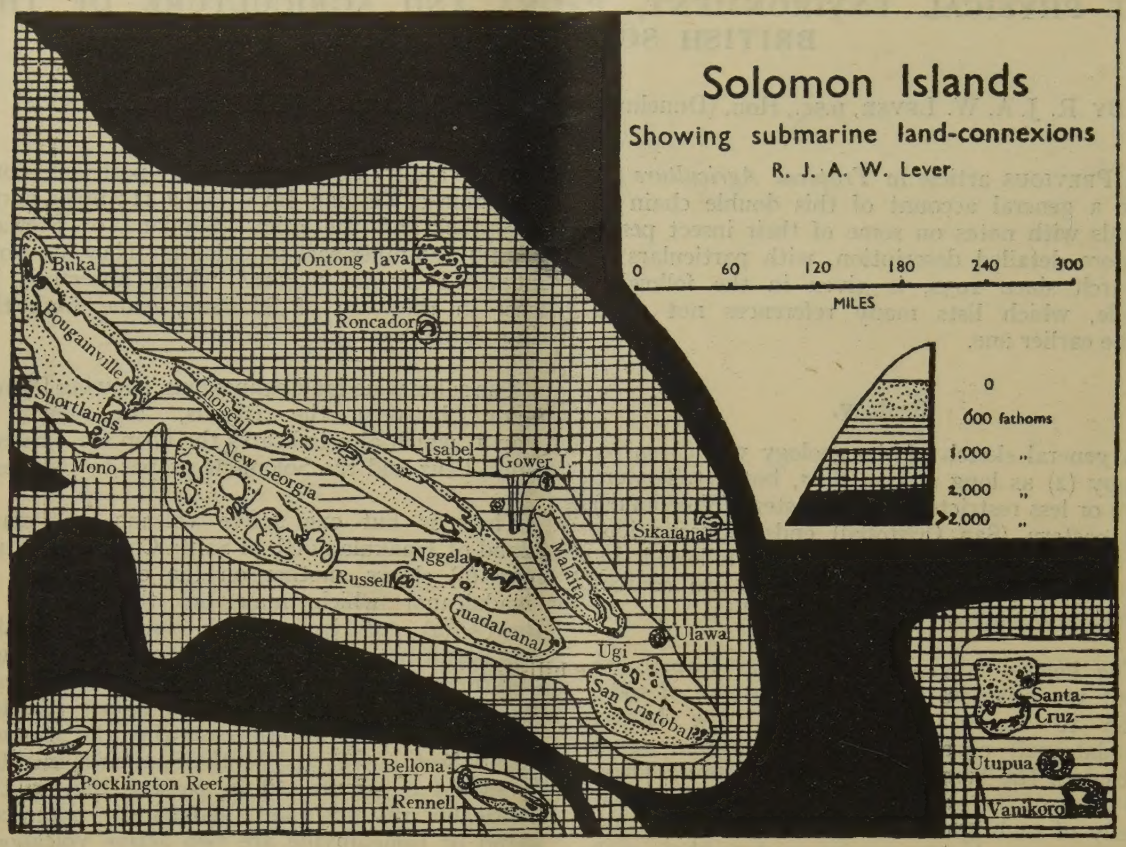
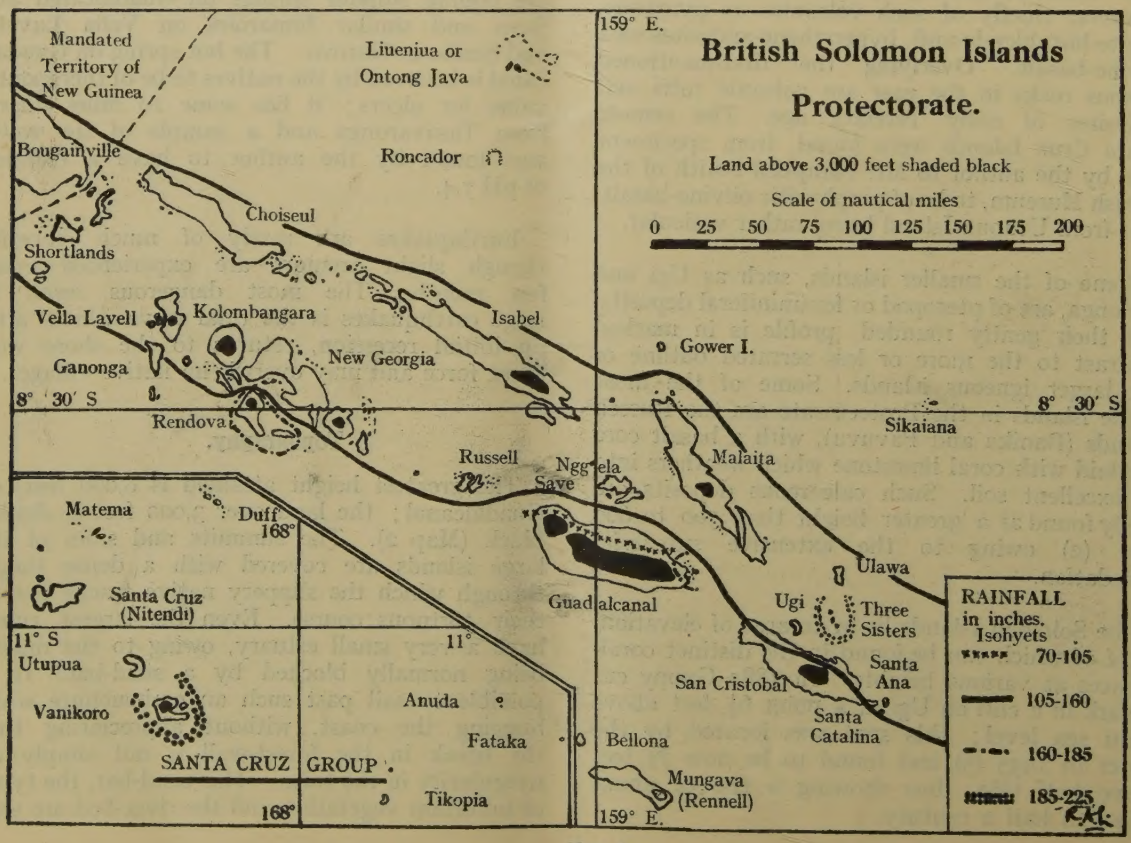

Solomon Islands
Showing submarine land-connexions
R. J. A. W. Lever
0 60 120 180 240 300
MILES
0
600 fathoms
1,000 ,,
2,000 ,,
>2,000 ,,
Buka
Bougainville
Shortlands
Mono
Ontong Java
Roncador
Choiseul
New Georgia
Isabel
Gower I.
Sikaiana
Nggela
Russell
Malaita
Guadalcanal
Ugi
Ulawa
San Cristobal
Santa Cruz
Utupua
Vanikoro
Bellona
Rennell
Pocklington Reef

MAP 1.


Mandated Territory of New Guinea
Liueniua or Ontong Java
159° E.
British Solomon Islands Protectorate.
Land above 3,000 feet shaded black
Scale of nautical miles
0 25 50 75 100 125 150 175 200
Bougainville
Roncador
Choiseul
Shortlands
Vella Lavell
Kolombangara
Isabel
Gower I.
Ganonga
New Georgia
8° 30′ S
Rendova
Sikaiana
Russell
Nggela
Save
Malaita
Matema
Duff
168°
Ulawa
Santa Cruz (Nitendi)
Guadalcanal
Ugi
Three Sisters
11° S
11°
Utupua
Santa Ana
San Cristobal
Vanikoro
Anuda
Santa Catalina
Fataka
Bellona
SANTA CRUZ GROUP
Mungava (Rennell)
Tikopia
168°
159° E.
RAINFALL in inches. Isohyets
70-105
105-160
160-185
185-225

MAP 2.

FIG. 1.—River Pui pui, San Cristobal Island. Note sandbar at mouth which is periodically washed away during storms in the hills behind which are over 3,000 feet high.

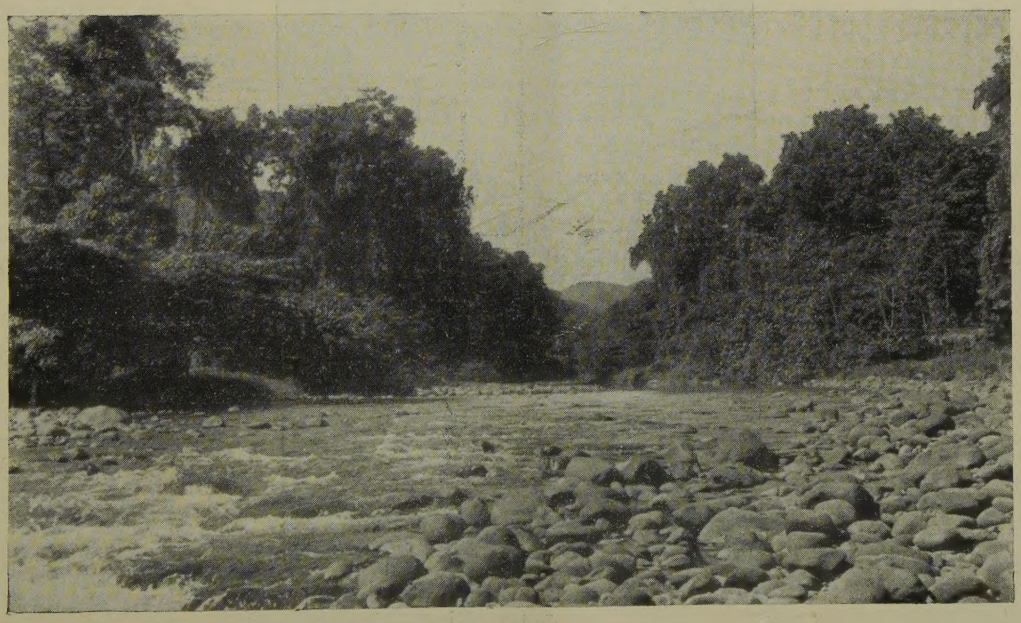


FIG. 2.—River Sorvohio, Guadalcanal Island.

FIG. 3.—Prairie country, northern coast of Guadalcanal Island. Grasses are *Imperata cylindrica* (lalang) and *Themeda australis*. Mountains in background are 3,400 feet high.

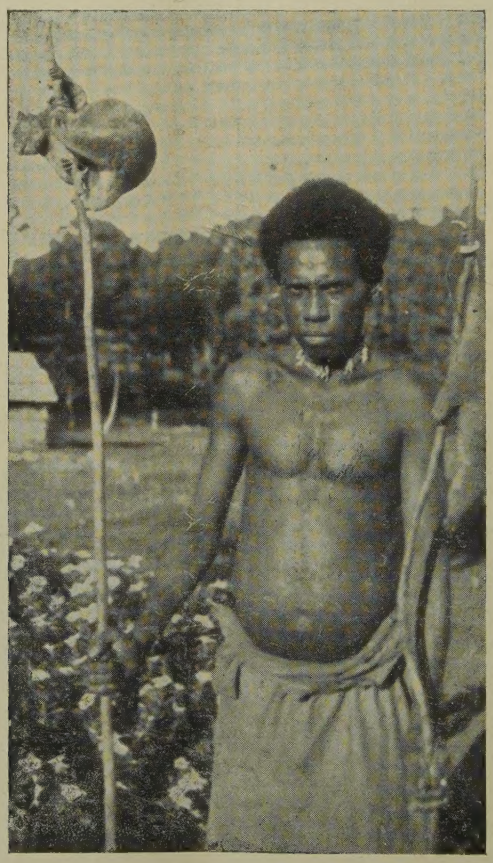


FIG. 4.—*Phalanger orientalis*. Native opossum Kira Kira, San Cristobal Island.

in Figures 1 and 2. The north coast of Guadalcanal is unique in having a coastal plain varying from 6 to 12 miles in depth which is covered with coarse grass (Fig. 3); this special feature will be dealt with later. Elevated ridges covered with jungle occur in these plains and elsewhere, and are found to be of coral of living types.

Of great interest is Rennell (Mungava), situated 100 miles south of Guadalcanal, but whose longitude is still uncertain. This island is considered to be the best example known of an elevated atoll, the former rim being a coral cliff some 500 feet high, while the eastern end has a lake occupying part of the former lagoon. The people are of Polynesian stock with some Melanesian admixture. This lake (Tungano) is of fresh water and is the largest in the South Seas. An analysis of the various salts was made in California, and appears in the middle of a systematic paper (7) on reptiles: the hydrogen ion concentration is not stated.

Soils.

The soils vary from red clays to dark and corally sands and have a correspondingly diverse physical structure. Analyses of soils from three islands were made at the Imperial Institute and are compared in tabular form below. That from Malaita has already appeared in print (8).

Detailed pedological studies on the other islands await the soil chemist. A red clay, apparently similar to that of Upolu Island in Samoa and believed there by Buxton (9) to be a rotted tuff, is found on Tulagi, east Guadalcanal, Malaita and east San Cristobal in the Solomon Islands.

Climate.

The latitude (7° to 12° S.) by itself indicates the climate to be expected, as does the scattered nature of the land-mass surrounded by the thermostatic Pacific Ocean. The most noteworthy feature is the total absence of the distinct wet and dry seasons so characteristic of Fiji and Samoa. The year is, however, climatically divided into two according to whether the south-east Trades (blowing from March till November) or the intermittent north-west Monsoon (from November till March) prevail. Hurricanes are very rare, and are even said to be unknown (10), but in December, 1935, the Santa Cruz Islands were in the centre of such a gale which wrecked a ship on Santa Cruz, stripped Utupua of its foliage and blew down houses on Vanikoro. Hurricanes then are sometimes found north of 12° south of the equator, but only very rarely.

TEMPERATURE.—The mean maximum and minimum temperatures in the capital (Tulagi I., Nggela) are 88° and 75°F., with an absolute maximum and minimum of 94° and 72°F.; Crichlow (11) gives 70° to 90°F. December is the hottest and August the coolest month and as February is the wettest and September the driest month it will be seen that the most trying weather is in the beginning and end of the year when the greatest temperature and rainfall virtually coincide. The only reference to inland temperature seems to be a record of 49°F. at 6,000 feet (10), though this may be doubted in view of Baker's data from the New Hebrides where 62.6°F. was recorded at the same elevation (12a). Readings at or near sea-level but not in a Stevenson screen, are 74° to 80°F. (minimal) and 91° to 102°F. (maximal) in the crown of a coconut palm (38). The prairie portion of Guadalcanal has lower figures owing to cold winds which blow from the mountains at night; records taken by the writer inside tussocks of grass are 65° to 72°F. and 95° to 104°F.

RAINFALL.—Over a range of 700 miles* there is naturally much variation in precipitation, which is shown by the isohyets on Map 2. An average rainfall of 120 inches at Tulagi is given for the period 1898 to 1910, 107.11 from 1911 to 1921 and 126.7 inches from 1926 to 1935; the last can be regarded as a good average figure. Contrasted with this is an average of 190 inches for

*The full extent of the Protectorate is politically as far as the minute islands of Anuda and Fataka lying 200 miles east of Vanikoro, making a total range of 900 miles. These specks of land have been ignored for the purpose of this survey.

Locality.	Depth.	Coarse and fine sand.	Silt.	Clay.	$CaCO_3$.	pH.	P_2O_5 soluble in HCl.
Malaita ...	6 in.	6.7%	13.6	61.0	Nil.	6.95	0.24%
	1 ft.	2.7	5.8	75.1	Nil.	6.8	not determined.
	1½ ft.	2.1	5.8	73.3	Nil.	6.7	0.30
	2 ft.	2.6	7.8	83.3	Nil.	6.5	0.41
Guadalcanal ...	6 in.	32.8	21.8	31.8	Nil.	6.7	0.005
	1 ft.	37.6	21.5	32.7	Nil.	6.8	0.001
	1½ ft.	33.2	23.1	32.5	0.18	6.8	0.001
	2 ft.	46.5	15.6	30.9	0.16	6.9	trace.
Russell Is. ...	6 in.	11.3	9.3	66.0	1.70	7.3	1.25
	1 ft.	0.9	1.9	87.2	0.34	7.2	not determined.
	2 ft.	1.2	1.2	86.1	0.34	7.2	

the Three Sisters north of San Cristobal and of 220 for Vanikoro, Santa Cruz, which has the highest rainfall in the Protectorate. At the other end of the scale is the northern plain of Guadalcanal with an average of 70 to 105 inches, one area having only 70 to 85, with a recorded minimum of 45 inches per year. As mentioned before, February is the wettest month and September the driest; Baker (12b), quoting Robson, states December is the driest, though it really comes about half way in a table of the months arranged according to the amount of rain. The seasonal index (the ratio of the rain in the wettest to the driest month) is 5.5, comparing with 2.5 for the New Hebrides, whose climate is therefore less variable. Guppy (14) estimated the rainfall at a height of 5,000 to 8,000 feet on Guadalcanal as 450 to 600 inches; the actual figure is still unknown.

HUMIDITY.—The relative atmospheric humidity at Tulagi—a small island off the south coast of Nggela—is 82 per cent., with a range of 75 and 87; the times of observation are 9, 12 and 16 hours. This is the only locality where this aspect of the climate is recorded and where there is a Stevenson screen and qualified meteorological observer.

SUNSHINE.—Two Campbell-Stokes sunshine recorders were ordered by the writer and records of bright sunshine have been obtained on two islands for over a year. The average sunshine per day per month was 6.1 hours on Guadalcanal and 5.7 hours in the Russell Islands. The highest individual daily record was 10.9 hours in October; the highest and lowest monthly totals were respectively 228.6 (September) and 152.1 hours (May). Tothill (13) suspected that four coconut estates were in areas with too much rainfall and too little sunshine ever to be profitable.

General Fauna.

It is not intended to deal with the fauna in any detail, as when this is attempted little progress can be made except in a few groups which have been thoroughly collected, such as the birds, reptiles and amphibians. Any systematic work on other phyla is at once held up by the paucity of identifications and this is also applicable to the insects, with the possible exception of the butterflies.

The first mention of the fauna of these islands appears to be Wallace (15) who groups them in the Papuan area through the presence of the red lory (*Eos*) and the white cockatoo (*Cacatua*). The fauna of all the islands from San Cristobal and westwards has an affinity with New Guinea, which is explained by a land-bridge *via* the Bismarck Archipelago (New Britain and New Ireland). As neither the hornbill (*Rhyticeros*) nor *Cacatua* occur in San Cristobal, this may have been the first island to be separated from the remainder of the land-mass in late Mesozoic times (16). The great depth of water between this island and Santa Cruz has been mentioned under Topography and these latter islands show resemblances to Queensland and Fiji in the presence of *Mictis profana* F. (Coreidae), to the New Hebrides in having *Promecotheca opacicollis* Gestro (Hispidae) and to New Caledonia in the kauri-pine (*Agathis*). A line between the Solomons proper and the Santa Cruz Islands will divide the Papuasian and Melanesian sub-regions, though Mann (17) draws the line in the Santa Cruz Islands between Vanikoro and the other islands to the north-west. What is now New Guinea can be regarded as the former land-mass which was the *fons et origo* of the fauna of the Solomons, with some migration across the present shallow Torres Strait: this will be a sound hypothesis for most distributional problems.

Mammals.

The most interesting mammal is the "cuscus" (*Phalanger orientalis breviceps* Thomas), Fig. 4, as it provides the extreme eastern extension of the marsupials. It is said to be probably absent (10) from San Cristobal but it has since been taken on that island (16), though it is absent from the Santa Cruz Group. Woodford (18) argues that it has arrived on the traditional floating log or in canoes from the Bismarks, but it seems less anomalous to regard it as having crossed on the land-bridge formerly connecting the Solomons and New Guinea where the sea-bed near the present coast is only 1,000 fathoms deep. At least 17 species and sub-species of bats are known from these islands, which should be compared with a total of 7 from the New Hebrides (19). Five species of native rats (including the huge *Mus gigas*, *M. rex* and *M. salamonis* have the body up to 14 inches long exclusive of the tail) are described, comparing with but one indigene in the New Hebrides (19). The route of these rodents has been shown by Tate (20) to be from the East Indies *via* New Guinea. Whales and porpoises and the dugong (*Halicore*) are not dealt with here except to mention that a probably unknown species of *Ziphius* was seen but not collected at Mono or Treasury Island (14). Guppy also deals with the vexed question of anthropoid apes on certain of the islands. Specimens of alleged hair of these animals have twice been brought to the present writer; in both cases they were vegetable fibre.

The bulk of the inhabitants are Melanesians of Papuan stock with varying admixtures of Polynesian blood. Those from the Shortland Islands are black, the rest being of different shades of brown. The average height was found by Guppy (14) to be 5 feet 4 inches (1.625 metres), with a cephalic index in the western portion of 78.7, which is mesocephalic; 74 in the east (dolichocephalic) and "almost brachycephalic" on north Malaita with 81.2.

The natives of the atolls previously mentioned are evidently descendants of Polynesians who had travelled with the prevailing Trades from the vicinity of Samoa. The ancestral home of the Sikaiana people is given as Lua'hatu, comparable with the Hawaiki of the Maoris. Their height to-day is much greater than that of Melanesians; two men and two women selected at random by the writer were found to measure respectively 5 feet 10½ inches and 5 feet 8 inches and 5 feet 6½ inches and 5 feet 5½. It would be impossible to obtain these figures in a Melanesian community, except perhaps by specially choosing tall individuals. Of the total native population of 93,500 only some 3,800 are Polynesians. The number of indentured labourers stands at about 3,100; they sign on for a period of two years and receive 10/- Australian (7/6 sterling) per month and all found. The hours of work per week are fifty and the bulk of the labourers comes from the island of Malaita, which has a population of 40,000 out of a total Melanesian population of 89,500.

Common diseases are malaria (chiefly sub-tertian), tuberculosis, hookworm, influenza and yaws, while bacillary dysentery is sometimes prevalent; leprosy also occurs.

Pigs and domestic fowls were seen by the Spaniards during their six months' visit in 1568 and Guppy in the early eighties saw wild dogs in the Shortlands (14). These are obviously all introduced animals and the pig plays a great part in the social life of the natives.

Birds.

Birds have been fairly thoroughly collected, at least near the coast, especially by the American Whitney South Sea Expeditions (22). As with other groups, the avifauna is largely of Asiatic origin; this holds good for Fiji and Polynesia (9), where the thinning-out and replacement by "oceanic species is seen going eastwards, as each tract of open sea is encountered. Mention has already been made of the absence of two conspicuous birds from San Cristobal whose adjacent small islands have their own sub-species of honey-eaters (Meliphagidae) and flycatchers (Muscicapidae). Australian and Asiatic derivatives are seen in the presence of 12 species of kingfishers (*Halcyon*), compared with only 4 in the New Hebrides (19), wild duck (*Anas superciliosa*), roller (*Eurystomus*), flycatcher (*Rhipidura leucophrys*) and heron (*Demigretta* and *Nycticorax*). As a new genus of flycatchers (*Guadalcanaria*) had to be erected for a bird shot in the interior of Guadalcanal as recently as 1929, there must still be additions to be made to the avifauna when the mountains of the larger islands are explored thoroughly.

Reptiles and Amphibians.

These have also been collected extensively by American workers, the bulletin by the Burts (23) having added to the fauna 6 lizards and 2 snakes previously recorded from the East Indies. The Solomons are so rich in purely endemic forms that no fewer than 7 frogs, 9 lizards and 6 snakes are peculiar to this relatively small, if scattered, land-mass. Species found also in New Guinea but not east of the Solomon Islands (exclusive of Santa Cruz) are 2 species of *Rana*, 4 skinks and 6 snakes.

The crocodile of N. Australia, *Crocodilus porosus* (Schneider), has its extreme limit on Tikopia (23), a small island 125 miles south-east of Vanikoro, Santa Cruz. Guppy (14) says its usual diet in the western Solomons appears to be the marsupial *Phalanger*; this animal is, as mentioned before, absent from the Santa Cruz Islands. Small volcanic pebbles were found in the intestine by the present writer; whether these have the triturating function of those in the crop of gallinaceous birds is not clear.

The monitor lizard, *Varanus indicus* (Daudin), locally miscalled the 'guana,' extends from Celebes and Queensland (14) and from Guam through the D'Entrecasteaux Islands (23) to the Santa Cruz group. It has a bifid penis.

A skink, *Lepidodactylus lugubris* (Duméril and Bibron), has been added to the Solomon Islands fauna from specimens sent by the writer to Mr. H. W. Parker of the British Museum. The Burts (23) did not take this lizard south of the equator to the west of Fiji.

Venomous snakes are represented by two species of *Denisonia* and *Micropechis* (Elapinae) and two species of the marine *Laticauda* (Hydrophiinae). Technically venomous are *Boiga* (Boiginae) and *Ahaetulla* or *Dendrophis* (Colubrinae). Three species of *Enygrus* (Boinae) occur, as against 2 in the New Hebrides (19): Baker here states that the crocodile occurs in Fiji, which is incorrect. Turtles, especially *Chelone mydas* L., are common, thereby differing from Samoa where turtles, crocodiles and amphibia are all absent (9).

Next to no work has been done on fresh-water fish as Protectorate regulations forbid the use of dynamite, which Baker in the New Hebrides (19) showed to be essential for collecting, as it was better than trammel net and lines. This writer believes that all the fish and eels taken in the New Hebrides are capable of living in the sea, in which he agrees with Buxton (9), who states that no genuine fresh-water fish occur in Samoan streams and swamps. The writer has had from the Solomon Islands the following determinations from Mr. J. R. Norman of the British Museum; these are all non-oceanic: *Periophthalmus barbarus* (Linn), from mangroves, *Chonophorus ocellaris* Cuv. & Val. (goby) and a blenny (*Salarias*), all clearly from brackish water.

(*To be continued.*)

A NOTE ON THE ACIDITY OF MANGROVE SWAMP SOILS.

By H. C. Doyne, M.A., A.I.C.
(*Department of Agriculture, Nigeria.*)

In a previous paper in this Journal (1) dealing with mangrove swamp soils in Sierra Leone, it was shown that the pH of soils which contained mangrove roots was often below 3. During 1934, clearing and cultivation of mangrove swamps in Nigeria for swamp rice was started, and a large number of soil samples was collected. The results of pH determinations on these soils were substantially the same as occurred with the Sierra Leone swamps, viz.; that mud which contained mangrove roots had an extremely low pH value of 3 or less after air-drying in the normal routine of soil analysis.

Subsequently 12 soil samples were taken to a depth of nine inches from land which had been cleared of mangroves, and from which one season's crop of rice had been taken. The samples were immediately stored in their wet state in screw top bottles, and the pH (quinhydrone method) was determined on portions removed from the bottle as soon as possible. The excess water was poured out of the bottles leaving the soils in a moist state. After two weeks' storage, portions of soil were removed from the bottles and air-dried and the pH then determined. (*See* Table 1.)

Table 1.

Reaction of Mangrove Swamp Soils.

Sample No.	Wet. Immediately after sampling.	Air-dry. After 2 weeks' storage in a moist state.
4305	5.8	3.6
4306	5.9	3.6
4307	5.4	3.6
4308	5.9	3.5
4309	5.2	3.4
4310	5.8	3.6
4311	5.9	3.9
4312	5.9	4.2
4313	5.15	3.4
4314	5.6	3.6
4315	5.0	3.0
4316	5.5	3.2

Storage and air-drying caused a decided increase in acidity. The remaining portions of the samples were kept in the dark with the tops of the bottles screwed down. About every fortnight the bottles were opened and samples taken for pH determinations. Before being returned to storage, the contents of the bottles were thoroughly stirred. The results are stated in Table 2.

Table 2.

pH Values determined every Fortnight on moist Soils.

Soil No.	Original.	1	2	3	4	5	6
4305	5.8	5.1	4.2	3.2	2.3	1.9	1.7
4306	5.9	4.9	3.4	2.9	2.3	2.3	1.9
4307	5.4	4.1	3.75	3.3	2.3	2.3	2.5
4308	5.9	4.9	3.6	2.9	2.1	2.1	1.85
4309	5.2	4.7	3.4	2.4	1.8	1.7	1.6
4310	5.8	5.2	3.1	2.15	1.3	1.5	1.3
4311	5.9	5.2	3.4	3.0	1.9	1.5	1.6
4312	5.9	5.4	5.0	3.8	2.3	2.0	2.0
4313	5.15	4.2	2.7	2.8	2.1	1.9	1.9
4314	5.6	4.5	3.7	3.95	3.0	2.8	2.6
4315	5.0	3.5	1.6	1.5	1.5	1.4	1.3
4316	5.5	4.1	1.9	2.1	1.5	1.5	1.7

The startling increase in acidity shown on storage was accompanied by the appearance of orange streaks presumably of ferric hydroxide, and by the presence of soluble sulphates.

The samples from the last pH determination (6) were air-dried, and the pH again determined. The air-dried soils were then repeatedly washed with hot water until they showed signs of peptization. The pH was then determined on the washed soils. The results are shewn in Table 3.

Table 3.

pH Values.

Soil No.	After 12 weeks' storage.	Air dried.	Air dried and washed.
4305	1.7	1.8	4.1
4306	1.9	1.6	3.7
4307	2.5	2.2	4.2
4308	1.85	1.5	3.75
4309	1.6	1.5	3.6
4310	1.3	1.8	4.15
4311	1.6	1.3	3.8
4312	2.0	1.5	4.0
4313	1.9	1.7	4.3
4314	2.6	2.5	4.2
4315	1.3	1.2	3.8
4316	1.7	1.4	3.9

Obviously a great deal of the acidity is due to the formation of water-soluble compounds, and the probable explanation is that ferrous sulphide is present in the soils in their natural state. The slow oxidation which these soils undergo on storage with stirring at intervals gives rise to ferrous, and later ferric, sulphate which is hydrolysed to ferric hydroxide and sulphuric acid.

The amount of soluble chlorides present in these soils was small, varying from 0.02 to 0.1 per cent. as compared with quantities of 0.4 to 1.0 per cent. in the rains in Sierra Leone. The explanation that the acidity of these mangrove soils is due to the liberation of exchangeable hydrogen by the cations present in salt water can hardly apply to these Nigerian soils, although there is no reason to suppose that it does not occur where the salt concentration is high.

Summary.

1. pH determinations were carried out at intervals on surface soils from a rice field which had been cleared of mangrove in 1934, the samples being stored in screw-top bottles in a moist state.

2. The initial pH values, determined soon after sampling, were between pH 5 and pH 6. Slow air-drying gave figures between pH 3 and pH 4. Subsequent determinations made at intervals of a fortnight on the same soils kept in a moist state showed a steady reduction to ultimate values between pH 1 and pH 2.5.

3. The increase in acidity was accompanied by the production of ferric hydroxide and water-soluble sulphates.

4. After repeated washing with hot water, the pH of the air-dried soils was raised from pH 1-2.5 to pH 3.6-4.3.

5. The decrease in pH values on storage is probably due to the formation of ferric sulphate from ferrous sulphide by oxidation.

6. Owing to the small amounts of soluble chlorides present, it is unlikely that the increase in acidity is due to the exchange action of sodium chloride.

Acknowledgments.

I wish to express my thanks to Captain J. R. Mackie, Director of Agriculture, Nigeria for permission to publish and to Mr. K. T. Hartley, Agricultural Chemist, Nigeria, for many useful suggestions in the compilation of this paper.

Reference.

1. Doyne and Glanville.—"Some swamp rice growing soils in Sierra Leone." *Tropical Agriculture*, Vol. X, No. 5.

THE LATE SIR EDWARD DAVSON.

It is with the greatest regret that we record the death in London, on 6th August, at the age of 62, of Sir Edward Davson, Bt., K.C.M.G., who had been a Governor of the Imperial College of Tropical Agriculture since 1924. During his brilliant career Sir Edward not only rendered invaluable services to the West Indies and British Guiana but also to the Colonial Empire as a whole.

The second son of the late Sir Henry Davson, head of the firm of Messrs. Henry K. Davson & Co., West Indian Merchants, he went to Eton in 1888. On leaving school he entered his father's business in which he became a partner and acquired considerable knowledge of the West Indian trade and was also inspired to study the general problem of Imperial trade development. He was a great believer in the necessity for closer cooperation between the Colonies and in 1916 founded the Associated West Indian Chambers of Commerce of which he was elected President, remaining in that office until 1926. He also founded the West Indies Conference and presided at the first Conference held in Barbados in 1929. He became Chairman of the Federation of Chambers of Commerce of the British Empire, serving that body ably from 1925 to 1928. As a representative of the colonies and protectorates on the Empire Marketing Board from 1926 to 1933, he went on missions to West Africa in 1926 and to East Africa in 1927 when he investigated Empire development with particular reference to scientific research. In 1930, Sir Edward succeeded Lord Melchett as Chairman of the British Empire Producers Organisation which he entirely overhauled. In 1932 he went to the Ottawa Conference as Government Adviser on Colonial trade. In addition, he was the representative of the Colonies and Protectorates on the Imperial Economic Committee, a member of the Colonial Development Committee, a trustee of the Imperial Institute and vice-chairman of the board and member of the London Committee of Barclays Bank (Dominion, Colonial and Overseas).

Sir Edward was knighted in 1919, made a Baronet in 1927 and a K.C.M.G. in 1934. He married in 1921 Margot Elinor Glyn, O.B.E., elder daughter of the late Mr. Clayton Glyn and Mrs. Elinor Glyn, the novelist, and had two sons.

Sir Edward who paid several visits to the College took an active interest in its work and welfare and his wise counsel, influence and support as a Governor will be greatly missed. To Lady Davson, her two sons and the members of the family we extend our sincere sympathies.

ERRATUM.

Vol. XIV, No. 8, facing p. 245. Caption Fig. 2. For B. *T. ortygnus*, male × 3 *read* B. *T. ortygnus*, male × 2.

TROPICAL FRUITS AND VEGETABLES. AN ACCOUNT OF THEIR STORAGE AND TRANSPORT.

By. C. W. Wardlaw.
Low Temperature Research Station.

(Continued from *Tropical Agriculture*, XIV, 9, 1937.)

Persimmon.

The Japanese persimmon, kaki, or date plum (*Diospyros kaki*), native to China, has become widely distributed in tropical and sub-tropical regions. In Japan, where more than 800 varieties are cultivated, of which perhaps 90 may be valuable, it is considered one of the more important fruits (19). Large areas are also devoted to its production in China. Indeed, in China and Japan the kaki has been described as occupying a place comparable to that of the apple in the United States (1). To a lesser extent it has also been taken into cultivation in Queensland, India and the Mediterranean region. Popenoe (19) considers that it is not improbable that the persimmon may become an important orchard crop in the United States cotton belt and in California. As a rule persimmons do not produce fruit so abundantly in moist tropical lowlands as in semi-arid sub-tropical regions.

The fruit has a thin membranous skin, and is orange-yellow to reddish-orange in colour. The soft, almost liquid, orange-coloured pulp is sweet and of pleasant flavour: analyses indicate 14-17 per cent. of sugars and 21-25 per cent. total solids. Seeds are usually present, from 4 to 8 in number, but seedless varieties are also known. The ripening fruit is characterised by a certain astringency which must be removed before the full attractive flavour of the pulp can be enjoyed.

Picking Maturity.

Fruit intended for export to distant markets should be harvested, using clippers or shears, when full-grown but firm (2); persimmons will ripen well if picked at this stage. According to Williams (20), the fruit keeps particularly well until it is eating ripe; thereafter it breaks down quickly and rapidly succumbs to moulds. Great care should be taken to avoid bruising, as injured fruits decay quickly (1).

Astringency.

Although some Japanese writers classify persimmons according to their astringency or sweetness, it has been pointed out that such a classification is untenable since certain varieties fall into the sweet group when carrying seeds and into the astringent group when seedless (19). Again, it is known that in some varieties the presence or absence of astringency is to some extent determined by environment (1, 2). The question of flesh colour in the presence or absence of pollination has been considered in detail by Hume. The following quotation from Hume cited by Popenoe (19) is instructive.

"Some of the varieties have dark flesh, others light flesh, still others a mixture of the two. The light and dark flesh differ radically in texture and consistency, as well as in appearance, and when found in the same fruit are never blended, but always distinct. The dark flesh is never astringent, the light flesh is astringent until it softens. The dark-fleshed fruit is crisp and meaty, like an apple, and is edible before it matures. Some of the entirely dark-fleshed kinds improve as they soften, like Hyakume and Yeddoichi; others are best when still hard, like Zengi. As they are good to eat before they are ripe, it is not so important that the dark-fleshed kinds be allowed to reach a certain stage before being offered to consumers unfamiliar with the fruit. The light-fleshed kinds, and those with mixed light and dark flesh, are very delicious when they reach the custard-like consistency of full ripeness. In some the astringency disappears as the fruit begins to soften, as with Yemon, and in a less degree with Okame, Tane-nashi; in others it persists until the fruit is fully ripe, as with Tsuru. The light-fleshed kinds should not be offered to consumers unacquainted with the fruit until in condition to be eaten. A person who has attempted to eat one of them when green and "puckery" will not be quick to repeat the experiment. The "puckery" substance in the immature persimmon is tannin".

Leoncini (13) has shown that in fruits with perfect seeds smaller quantities of tannin and mannan are present than in the fruits of seedless, astringent varieties. By using the expressed juice of astringent Japanese persimmons, Kakesita (11, 12) showed that the addition of acetaldehyde, and other aldehydes, led to coagulation of the tannic substances at room temperature; it is thought that a polymerisation of tannic substances is induced with formation of an insoluble tannin-colloid, whereby astringency is removed. Kakesita also considers that the removal of astringency is associated with the introduction of intramolecular respiration; he showed that the immersion of fruits in a warm water bath—a recognised method for removing astringency—was accompanied by the formation of acetaldehyde in the fruits.

It will be noted that the effect of pollination, determining the presence or absence of seeds, on the character of the fruit flesh, is of considerable practical importance: seeds always accompany the dark-fleshed condition, while light-fleshed

types may or may not be seedless. The amount of dark flesh is determined by the number and position of the seeds; for example, the presence of one seed causes a zone of dark flesh to appear in the vicinity of that seed only, the remainder of the flesh being pale coloured; and so on for two, three or more seeds until the entire central region, associated with the placentae, is dark in colour (2).

The astringency of unripe fruit is thought to be due to the presence of soluble tannin in the cells (2). As the fruit matures the tannin becomes progressively more insoluble until it is no longer perceptible, to the palate, in the fully matured fruit. This view is not accepted by all workers. Thus Lloyd (15) considers that the tannin, which occurs in strands of cells distributed through the pulp, is associated with a mucilage-like carbohydrate which coagulates during fruit ripening and absorbs the tannin. In some varieties, the absorbed tannin becomes oxidised and red in colour, so that the tannin masses are easily recognisable.

Removal of Astringency.

Several methods are employed to remove astringency, including: (i) storing in closed containers or casks containing saké (Japanese rice beer) for 1-2-3 weeks (2, 7, 8, 9); it has been shown that by enclosing fruits in tubs containing some dilute alcohol satisfactory ripening can also be achieved (8, 9); (ii) piercing fruits at the bottom end several times with a needle dipped in alcohol and packing in a tight box or container for 10 days (2, 14); (iii) immersion in hot water for 12 hours at 85°-105°F. (2); (iv) direct carbon dioxide treatment for 2 to 7 days (2, 7, 8, 17); and (v) treatment with ethylene (4, 10, 17).

Overholser (17) has given a detailed account of experiments on the removal of astringency in Japanese persimmons by the application of dilute vapours of ethylene chlorhydrin, ethylene chloride, and ethylene bromide, and by the gases ethylene and propylene. These organic compounds were found to hasten ripening and simultaneously to remove astringency. When ethylene was employed at a concentration of 1 part in 2,000 parts of air for 2½ days, the astringency, as a rule, was entirely removed five days later; as the fruits softened at the same time, however, the period of marketability was unduly curtailed; excellent colour, quality and flavour were obtained by this treatment. The exact details of the ethylene treatment for commercial consignments require further consideration. Harvey (10) cites applications of ethylene (1 part per 1,000) at 65°F. as giving a satisfactory removal of astringency within 50 hours.

Overholser's experiments also showed that if fruits are surrounded with CO_2 for 12-24 hours, or placed in closed containers for 4-6 days, the loss of astringency takes place sufficiently rapidly for commercial purposes and does not seriously shorten the period of marketability.

More recently, Davis and Church (4) have published a comprehensive account of the effect of ethylene on the colouring, softening, chemical composition and respiration of different varieties of persimmons, harvested at different stages of maturity. They have confirmed previous findings that ethylene stimulates softening, colour development and respiratory activity and decreases astringency. The stimulative effect of ethylene on respiration decreased and the respiratory quotient $\frac{CO_2}{O_2}$ increased as fruits underwent progressive maturation; these changes being particularly noticeable when final maturity was reached in stored fruit. Davis and Church have concluded that ethylene appears to act through its effect on the general metabolism.

Williams (20) states that with persimmons intended for cold storage, care should be taken to see that fruits are sufficiently ripe, otherwise the true flavour may not develop when they are removed from cold storage. Slightly unripe fruit should receive some treatment with ethylene. Here caution must be exercised or the fruit may become too soft to permit of satisfactory storage.

Packing.

Packing for shipment should be carried out as soon after harvesting as possible. The six-basket carrier is usually employed for consignments dispatched from Florida to northern markets, each fruit being wrapped (19). Californian fruit is wrapped in tissue paper and packed one or two layers deep in peach boxes, 19¾ × 12 × 5 inch, outside measurements, and weighing 18 lb. (2). It has been determined that wrapped fruit keeps better than unwrapped (20).

Storage Temperature.

The persimmon ranks as one of the fruits which behave well in cold storage, so much so that for centuries open-air cold storage has been practised in China (5, 6).

> "The open-air cold storage of persimmons in the vicinity of Peking is a unique and interesting practice and, so far as known, is peculiar to north-eastern China. By this method fruit in good condition and excellent quality may be had throughout the season from October until the middle or last of March. Meyer (16) records the following observations on the winter storage of persimmons:
>
> > By careful handling and by keeping the persimmons at a low temperature they can be preserved for several months. To keep them through the winter, the Chinese pile them in heaps, let them freeze thoroughly, and keep them frozen until they are needed. When wanted, they are simply put into a vessel with cold water, to be thawed slowly, and they are then as good as when freshly picked. They can also be eaten when slightly frozen like sherbet, and occasionally are quite acceptable in that condition.

"It is difficult to realize that practically the entire winter's supply of persimmons grown in the vicinity of Peking, amounting to many millions of fruits, is stored in beds, on the ground in the open, along the terraced river banks, in the orchards along the streams, in village compounds, and on river bottoms of sand and gravel, without protection of any kind other than a bed of kaoliang stems (a variety of sorghum) beneath and a covering of a single thickness of reed-grass matting which, after the fruit is frozen, is supplemented with a covering of dry mountain grass or other available litter to a depth of about 2 feet.

"The storage beds are simple affairs, usually about 12 feet in width and of any desired length. The bed is prepared by digging four trenches, which, with the dirt taken from them and piled on the sides, are about 12 inches in depth and about the same in width. A bed of kaoliang stems 3 to 4 inches in thickness is laid across the ridges, and upon this the fruit is placed by hand, in regular layers, generally six persimmons deep, sometimes fewer, but never more. The five bottom layers are placed with the stems of the fruit down, while the top layer is placed with the stems up. In some sections, especially in village compounds, timbers or logs are laid on the ground and take the place of the earth ridges, and the bed of kaoliang stems is rolled down over them. After the beds are filled with persimmons, kaoliang stems or other available litter is put about the ends and sides of the beds to protect the fruits from injury. They are then covered with a single thickness of reed-grass matting, which in some instances is tied down with small grass rope, while in others it is weighted down with small stones to prevent its being carried away by the wind. After the persimmons are frozen, this covering is supplemented by from 18 to 24 inches of loose, dry grass or other litter (6)."

The trenches and spaces under the persimmon beds serve for drainage in case of rain or snow, but their greatest importance is to allow of air circulation. This helps to reduce the temperature of the fruit in the beds at the time of storing, and in winter insures a more uniform freezing than otherwise would be possible.

Experiments with California grown persimmons showed that all varieties softened more quickly at 36°F. than at 32°F., and that fruits kept best at 30°F. Under these conditions fruits kept in good condition for 2 months, and, on removal from storage, remained marketable for 8 days. Most varieties have a tendency to shrivel, particularly at the apex; the use of relatively impervious wrappers is therefore advisable (2, 18).

In experimental trials with Australian-grown persimmons at 32°, 36° and 40°F., it was found that the best results were obtained at 32°F. with a R.H. of 85 per cent., the higher temperatures being conducive to more rapid ripening. No difficulty was experienced in holding fruit for periods up to 120 days (20).

Cruess (3) recommends storage of wrapped fruit packed in single layer flats, at a temperature of 32°-36°F.

References.

1. Camp, A. F. and Mowry, H.: The Japanese Persimmon in Florida. *Florida Agr. Exp. Sta. Bul.* 205, 1929.
2. Condit, I. J.: Kaki or Oriental Persimmon. *Univ. Calif. Agr. Exp. Sta. Bul.* 316, 1919.
3. Cruess, W. V.: How to Preserve Fresh Persimmons. *Pacific Rural Press*; *Agr. Gaz. New South Wales*, XLIII, 619, 1932.
4. Davis, W. B. & Church, C. G.: The Effect of Ethylene on the Chemical Composition and the Respiration of the Ripening of Japanese Persimmons. *Jour. Agr. Res.* XLII, 3, 1931.
5. Dorsett, P. H.: Chinese Method of Outdoor Cold-Storage for Persimmons. *Ice & Refrig.* LXXV, p. 242, 1928.
6. Dorsett, P. H. and Dorsett, J. H.: Culture and Outdoor Winter Storage of Persimmons in the Vicinity of Peking, China. *U.S. Dept. Agr. Circ.* 49, 1928.
7. Gore, H. C. & Fairchild, D.: Experiments on the Processing of Persimmons to Render them Non-Astringent. *U.S. Dept. Agr. Bur. Chem. Bul*, 141, 1922.
8. Gore, H. C. *et al.*: Large Scale Experiment on Processing Japanese Persimmons. *U.S. Dept. Agr. Bur. Chem. Bul.* 155, 1912.
9. Griffin, W. E.: Japanese Persimmons. *Calif. Hort.* VII, 1877.
10. Harvey, R. B.: Artificial Ripening of Fruits and Vegetables. *Univ. Minnesota Agr. Exp. Sta. Bul.* 247, 1928.
11. Kakesita, K: Preliminary Report on the Study of Artificial Removal of Astringency in the Kaki. *Proc. Imp. Acad. Tokyo*, VI, 397, 1930. *J. Soc. Chem. Ind. London*, L. 364B, 1931. *Chem. Abst.* XXV, 1600, 1931; (*Abstr. in Dept. Sci. Ind. Res., Index. Lit. Food Invest.* IV, 2, 1932).
12. Kakesita, K.: Artificial Removal of Astringency in the Kaki. *Agric. & Hort.* V, 1157, 1930. *Proc. Imp. Acad. Tokyo*, VI, 397, 1930; (*Abstr. in Dept. Sci. Ind. Res., Index. Lit. Food Invest.* IV, 2, 1932).
13. Leoncini, G.: Fruits with Normal and Fruits with Imperfect Seeds in *Diospyros Kaki* (trans. title). *Bol. 1st. Sup. Agr. Pisa* VI, 1930; (*abstr. in Dept. Sci. Ind. Res., Index Lit. Food Invest.* IV, 2, p. 95, 1932.)
14. Leoncini, G.: Effect of Artificial Wounds, Made at Various Periods, on the Ripening and Senescence of the Fruit of *Diospyros kaki* (trans. title). *Bol. 1st Sup. Agr. Pisa*, VI, 551, 1930. *Chem. Abst.* XXV, 4021, 1931.
15. Lloyd, F. E.: Behaviour of Tannin in Persimmons. *Plant World*, XIV, 1911.
16. Meyer, F. N.: Agricultural Explorations in the Fruit and Nut Orchards of China. *U. S. Dept. Agr. Bur. Pl. Indus. Bul.* 204, 1911.
17. Overholser, E. L.: Some Studies upon the Ripening and Removal of Astringency in Japanese Persimmons. *Proc. Amer. Soc. Hort. Sci.*, XXIV, 1927.
18. Overholser, E. L. & Hodgson, R. W.: Cold Storage of Persimmons. *Univ. Calif. Agr. Exp. Sta. Rept.* 1921-22.

19. Popenoe, W.: Manual of Tropical and Sub-Tropical Fruits. *Macmillan Coy., New York*, 1920.
20. Williams, W. J.: Cold Storage of Figs, Raisins, Persimmons, Quinces and Tobacco. *Ice and Refrig.* LXXXIX, 6, 1935.

Pineapples.

The pineapple (*Ananas sativus*), native of tropical America, has been widely distributed throughout the tropical and sub-tropical belt, and is now cultivated on a more or less extensive scale in Hawaii, Cuba, Florida, the West Indies, Brazil, the Azores, Canary Islands, Formosa, Singapore, Queensland, Ceylon and elsewhere. The plant is naturally suited to a dry, hot climate, but flourishes also in moist warm regions if drainage is good. Macmillan (20) states that virgin or jungle soils, under light shade, generally yield the largest and most luscious fruits.

Several varieties are known on temperate markets, including the Smooth Cayenne (Kew Pine)—a variety extensively grown in Hawaii, Florida, Azores, &c.—Red Spanish, Sugar Loaf, Black Antigua, Ripley Queen, Pernambuco and so on. A general account of pineapple cultivation is now available in book form (18).

Pre-Storage Factors.

Davies (8, 9) has pointed out that the pineapple plant is subject to considerable variation: careful selection of desirable types is therefore necessary to yield and maintain a good standard of produce for export. Good cultivation is also considered to be a pre-requisite in the production of good fruit.

In an early report, Blair and Wilson (6) state that the eating quality of pineapples, as indicated by acid and sugar content, does not appear to be affected by fertiliser treatments; possible effects on shipping quality cannot, however, be ruled out. By increasing the amount of fertiliser, the sugar content was slightly increased and the acid content reduced. It was observed that large fruits contain a greater percentage of sugars than small ones; the ratio of reducing sugars to sucrose is greater in large fruits than in small ones.

Changes during Ripening.

Analyses of pineapples published by various investigators indicate about 8 per cent. sucrose and 4 per cent invert sugars, *i.e.*, a total sugar content of approximately 12 per cent. These constituents show considerable variation according to season and variety. They also vary in different parts of the same fruit (18): the sugar content increases from the apex to the base of the fruit, while the acidity decreases. During the later stages of ripening on the plant, a marked increase in the sugar content and decrease in acidity takes place; fruits harvested green and immature tend to have a low sugar content and poor flavour on ripening. The increase in sugars during ripening has been attributed by Kelley (19) to the transformation of starch present in the stem into sugars, and their subsequent translocation to the tissues of the fruit. Analyses by Abel (1) and Horner (16), however, indicate that the normally developed fruiting plant as a whole loses no starch. "While there is probably some withdrawal of the starch from the reserve in the upper part of the stem, this is probably compensated by the activity of the leaves in manufacturing starch. With winter fruit the drain is probably greater than the manufacture. The development of slips and suckers causes a heavy draft on the starch reserves." (18).

Henricksen (12) in attempting to assess correct harvesting maturity has made the following observations on internal changes in fruits on the plant: the degree of maturity reached is discernible in the texture and flavour of the flesh and in the colour, taste, viscosity, and total solids content of the juice; immature fruit is firm and brittle and practically without pineapple flavour; as ripening progresses the flesh becomes increasingly tender and develops the characteristic flavour of the ripe fruit; the juice of immature fruit is milky white in colour, insipid, very viscous, with a total solids content of 9 per cent. or less; with maturation the colour changes to yellow, the taste mellows, the viscosity diminishes, and the solids content increases to a value of 14 to 15 per cent. in plant-ripened fruit; in exceptional instances 16 to 17 per cent. may be present, the basal region containing 2 to 4 per cent. more than the apex.

After the fruit is severed from the plant, sugar formation ceases. Acidity, as measured by titration, varies from less than 0.4 per cent. in immature fruit to upwards of 0.9 per cent. and occasionally more, in fully grown fruit. The degree of acidity is not regarded as a reliable indicator of maturity in pineapples.

Harvesting Maturity.

Flavour and aroma are most attractive in pineapples fully ripened on the plant. Such fruits are unsuitable for transporting to distant markets and a less mature grade must be selected. With some varieties this may present difficulties. Unless a certain stage of maturity has been reached at harvesting, normal ripening may not take place and the final quality will be poor. The first evidence of actual ripening is to be observed in the basal region of the fruit; the apical region also affords useful accessory indications. In the Red Spanish variety, as grown in Porto Rico, Hendricksen (12) and Hendricksen and Iorns (14) state that where the bracts below the "eyes" are still unwilted, the fruit is insufficiently mature for reaping. When the basal "eyes" show a slight yellowing, the fruit may be considered to have reached shipping maturity for short voyages without refrigeration; the same maturity is suitable for long journeys, provided refrigeration is available. More subtle variations in maturity depend to some extent on environment and local study is necessary to determine precisely the most suitable harvesting maturity for particular requirements.

The development of the crown, slips, "eyes", and bracts and the general colour may also be used in assessing maturity (15). As the fruit ripens, the crown opens out, the "eyes" open and become lighter in color; and the bracts wilt, then shrivel. In general, the more nearly ripe the fruit is at harvesting the better will be the quality; provided the "eye" margins are well rounded, the spaces between of a light greenish-yellow, and the leaflets wilted or withered, fairly good ripening colour and palatability may be expected; less mature fruit may apparently ripen, but the quality and colour will usually be poor (14).

Higgins (15) considers that Hawaiian fruit for shipment without refrigeration should be cut when green, provided the eyes in the basal region have acquired the pale green colour indicative of the commencement of ripening; during the cooler season slightly more mature fruit, in which the first traces of yellowing has appeared, may be harvested. For pineapples grown in Florida, Vosbury and Winston (25) state that the best harvesting maturity for export fruit is when the hard-ripe or "ruddy-ripe" stage has been reached, *i.e.*, when reddish-yellow ripening colour has appeared in fruits which are still firm.

For Queensland fruit, Benson (4, 5) considers that the best harvesting maturity for the summer crop is when the fruit has become fully developed, the "eyes" well filled out, and the basal region slightly coloured; such fruit is sufficiently mature to develop its full colour; the winter crop must be reaped when more fully coloured, otherwise it will be lacking in sweetness. Again, for Australian pineapples, Williams (29) and Barnett (3) state that fruit should be full grown and green, and showing only the slightest traces of ripening colour.

Harvesting and Packing.

Careful handling at all stages is essential (28) bruising being quickly followed by the inroad of soft rots. The fruits should be cut off from the plants and not broken, and placed in field boxes. A short wilting period of 1 to 2 hours in the sun is considered useful (15). The fruits are then transported to the packing house, placed on their crowns and allowed to cure (*i.e.*, cool and dry) for one or two days. The shipping of damp, uncured fruit is undesirable (14). The general requirements for packing-house construction and organisation are described in detail by Johnson (18). Grading and culling of unsuitable fruits should be carried out carefully to insure the export of high-grade consignments, standardised for maturity and quality. Sizing is chiefly by eye but sizing by gauge and by weight are also employed (18). Treatment with formaline and other disinfectants as a means of curtailing fungal wastage has not proved satisfactory (28).

Various types of pack, accommodating single or double layers of fruit, may be used. Fruits may be crated wrapped or unwrapped, but usually a packing of excelsior, wood-wool or fibre is used to reduce bruising. Davies (8) and others (7) consider that fruits wrapped in waxed or oiled papers not only make a more attractive pack but are superior to unwrapped fruits in that they retain their bright, fresh appearance. Wrapping encourages the growth of surface moulds, particularly on the crowns, but these may be left exposed.

Various sizes of crate have been used or recommended. Hawaii—large crate 40×17×15 inch, inside measurement, holding 130-150 lbs. of fruit (15); medium crate, 22¼×16×15½ inch, inside measurement. Porto Rico—standard crate for Red Spanish pineapples, 36×10½×12 inch, with a central partition; standard lemon and orange boxes are also used. Florida—packing methods similar to those in use in Porto Rico have been introduced by Hume (17) and Vosbury and Winston (25). New South Wales (3) and Queensland (5)—standard crate 24¾×12×12 inch, inside measurement, without a central partition. Azores—for shipment to the London market, fruit are packed 6-8-10 according to size, in a single layer, in a case measuring 40×21×8 inch, outside measurement; the unwrapped fruit is packed with dry sweet corn husks (5).

Recent export regulations for South African pineapples include the following (7): (*a*) pineapples shall be packed in single or double layers in boxes as laid down in regulations Nos. 16 (*d*), (*e*), and 17; (*b*) pineapples may have wood-wool, papyrus pith or grass approved by the Department of Agriculture, placed between the fruits; (*c*) when pineapples are packed without wood-wool, papyrus pith or grass, each fruit shall be wrapped in suitable paper; (*d*) all "Extra Selected" pineapples of the Queen variety shall weigh not less than 1½ lb. each, and of the Cayenne varieties not less than 4 lb. each; (*e*) all "Selected" pineapples of the Queen variety shall weigh not less than 1¼ lb. each, and of the Cayenne varieties not less than 2½ lb. each; (*f*) all "Choice" grade pineapples of the Queen variety shall weigh not less than 1 lb. each, and of the Cayenne varieties not less than 2 lb. each; (*g*) the whole crown shall be left on each pineapple in as perfect condition as possible; (*h*) pineapples shall have not more than ¼ in. of the stalk left on each fruit of the Queen variety, and ½ inch on the fruit of the Cayenne varieties; (*i*) all pineapples shall be in sound condition, fully developed, not too unripe, free from diseases, bruises, cuts, or any blemishes detrimentally affecting their appearance and shall be of the characteristic shape of their variety; (*j*) all pineapples shall be free from visible outward signs of the disease known as "Black Spot" (*k*) The Government Fruit Inspector shall have the right to cut open the pineapples from one box in each consignment exceeding 10 boxes for the purpose of keeping a check on the disease known as "Black Spot".

Rapid Cooling.

As pineapples ripen quickly at high temperatures rapid cooling after harvesting is essential (8, 9). Williams (28) states that on receipt at the packing

house, precooling to 55°-60°F. for two days is advisable, prior to placing fruits in the storage rooms.

Storage and Transport.

In the early days of pineapple exportation from Porto Rico to the United States refrigerated vessels were not available (21). By using various systems of ventilation, however, hold temperature in the region of 45°-47°F. could be obtained on the north-bound voyage; spoilage due to higher temperatures was not infrequent. Early shipments of pineapples from South Africa to England were also made without refrigeration (10). For transport from the Azores to Europe, a voyage period of about 10 days, storage in well-ventilated holds is sufficient; the pineapples remain in good condition for relatively long periods (2). For longer voyages, *e.g.*, three weeks, as from South Africa to England, the use of refrigeration is now considered indispensable.

As early as 1907, Higgins (15), discussing the possibility of exporting pineapples from Hawaii to San Francisco, called attention to the need for adequate control, during transport, of ventilation, humidity, and temperature.

Some account of pineapple transport from South Africa to England has been given by Davies (8, 9). Consignments of fruit were carried at a temperature of 34°-38°F., or 38°-40°F. as circumstances allowed. On being discharged the fresh condition of the fruit had apparently been maintained, but a few days later a rapid softening and leaky breakdown, with development of moulds, was the rule. According to Barker (2), South African pineapples are firm and bright in appearance on arrival but gradually become soft, dull in appearance and dark in colour; if left in the package moisture appears on the skin and mould may develop. Other experimental shipments (23, 24, 27) indicate that a temperature of 37°-39°F. does not provide suitable conditions for the transport of pineapples over long distances.

In storage trials with "Queen Pines" at the Low Temperature Research Station, Capetown, fruits were held at 32°, 35°, 40°, 45° and 50°F. for three weeks, then removed to outside air temperature. It was observed that normal ripening cannot take place at a lower temperature than 45°F., as chilling injury may be sustained. At 40°F. there was some evidence of low temperature breakdown after 3 weeks. At 45°F., although ripening is apparently normal, other factors, including a tendency to excessive wilting and the development of soft rots, become important. To some extent wilting may be curtailed by the use of waxed or oiled wrappers; these, however, favour the growth of superficial moulds. Different classes of fruit showed marked differences in keeping quality, the best giving 50 per cent. longer life than the average.

Pineapples grown in Porto Rico, if ripened on the plant and carefully handled, may be transported to the United States at a temperature of 35°-40°F. (12).

In storage trials with Australian pineapples, a temperature of 40°-42°F. was found to be too low (28); after two weeks, chilling symptoms, in the form of darkening at the core, were observed; the skin also showed evidence of injury. At the end of 4 weeks, an aggravated form of chilling, accompanied by breakdown and rotting, was in evidence. Fruits held at 45°-47°F. gave better results, but at the end of 4 weeks some internal discoloration had taken place. With fruits stored at 50°-52°F. and a R.H. of 85 per cent. good results were obtained over a period of 7 weeks; although the fruit slowly ripened, the green colour remained pronounced; the Queen variety kept better than the Ripley. Subsidiary experiments indicated that the materials used for packing must be absolutely dry. Under the conditions specified Williams (28) considers that the shipment of Australian pineapples to the English market should not prove impossible. Slightly coloured pineapples, stored at 55°F., developed further ripening colour in the course of four weeks, and a product of sweet quality was obtained. It is suggested that before being marketed fruit should be ripened for a few days at a temperature of 55°-60°F.

Henricksen (22) has reported that storage for one week of Porto Rico pineapples at 50°-60°F. only partly arrests the chemical changes associated with normal ripening; at this temperature considerable shrivelling may result. At a temperature of 35°-40°F., shrivelling is negligible and ripening changes in both green and colouring fruit are arrested; storage for 6 days at this temperature does not preclude normal ripening on removal to a higher temperature. From results obtained it is thought that fruits may be refrigerated at 35°F. for a short period, or at 41°F. for a longer period. Fruits ripened on the plant were protected, after harvesting, against desiccation by being coated with a thin layer of paraffin; when applied to immature fruits this procedure interfered with the proper coloration.

In storage trials with the Sugar Loaf variety in Trinidad (26) at 50° and 60°F.—temperatures specially selected to avoid chilling—some of the fruits became quite ripe in the course of 11 days, and over-ripe after 15 days with the production of an alcoholic aroma. Physiological core discoloration was absent. While the flavour of the ripe fruit was excellent, there was evidence of uneven ripening, and instead of the full yellow colour being produced, a dark or dingy yellow was the rule. Fruit which had ripened at 50°F. was of good flavour though noticeably more acid than that ripened at 60°F.; even in soft, fully matured fruit, the skin remained dark green; the flesh was also noticeably less yellow than in fruit ripened at 60°F.

Ripening with Ethylene.

While it is not customary to ripen pineapples prior to marketing by the ethylene treatment, Harvey (11) considers that such a procedure may offer advantages. Fairly mature fruits

are liable to suffer from fungal rots during shipment: on the other hand green fruits, which are more resistant and durable, and stand shipment well, may prove difficult to ripen unless specially treated. It is here that ripening with ethylene might find a useful application. By treating green fruits with ethylene gas (at the rate of one part per 1,000 parts of air, for 3-4 days at 65°F., at a low R.H.) Harvey (11) claims that ripening takes place and a product of attractive colour, flavour and aroma is obtained; the excess acidity disappears and the percentage of invert sugar is increased. The lack of uniformity in crated fruits or in the individual fruit, *i.e.* from apex to base, is removed. Propylene is said to give still better results.

References.

1. Abel, F. A. E.: Chemical Changes in Pineapple Stalks and Developing Fruit. *Pine News*, V. 2, 1928. (*Cited by Johnson.*)
2. Barker, J.: Wastage in Fruit Commerce. (South African Pineapples.) *Dept. Sci. & Ind. Res. Ann. Rept. Food Invest. Bd. for* 1927. *H.M. Stationery Office*, 1928.
3. Barnett, G. B.: The Pineapple. *Agr. Gaz. New South Wales, Misc. Pub.* No. 2817, 1931.
4. Benson, A. H.: Pineapple Culture in Queensland. *Bul. Queensland Dept. Agr. & Stock*, 1916.
5. Benson, A. H.: Pineapple Culture in Queensland. *Bul. Queensland Dept. Agr. & Stock, 7th Edit.* 1924.
6. Blair, A. W. & Wilson, R. N.: Pineapple Culture. IV.—The Effects of Fertilizers upon the Quality of the Fruit. *Fla. Agr. Exp. Sta. Bul.* 101, 1910.
7. Clark, L. H.: Pineapple Culture in the Eastern Districts of The Cape Province. *Union of S. Africa Dept. Agr. Pam.* 102, 1931.
8. Davies, R.: Pineapple Storage and Export. *Farming in S. Africa*, III, 1928.
9. Davies, R.: Fruit Storage Investigations. I.—Storage Investigations of Pineapples in S. Africa. *Union of S. Africa Dept. Agr. Sci. Bul.* 71, 1928. (*Ice & Cold Stor.* XXXII, 376, p. 170, 1929.)
10. Fuller, C.: Pineapple Export (Results of Natal Experiments). *S. Africa Agr. Jour.*, V, 2, 1911.
11. Harvey, R. B.: Artificial Ripening of Fruits and Vegetables. *Univ. Minnesota, Agr. Exp. Sta. Bul.* 247, 1928.
12. Henricksen, H. C.: Pineapple Investigations. *Porto Rico Agr. Exp. Sta Ann. Rept. for* 1928.
13. Henricksen, H. C.: Maturity Changes taking place in Refrigerated Pineapples. *Revue Internationale de Renseignements Agricoles, I.I.A. Rome*, Jan-March 1924, p. 72. (*Jour. Bd. Agr. Brit. Guiana*, XVI, 3, 1924).
14. Henricksen, H. C. & Iorns, M. J.: Pineapple Growing in Puerto Rico. *Puerto Rico Agr. Exp. Sta. Bul.* 8, 1909.
15. Higgins, J. E.: Marketing Hawaiian Fruits. *Hawaii Agr. Exp. Sta. Bul.* 14, 1907; The Pineapple in Hawaii. *Hawaii Agr. Exp. Sta. Bul.* 36, 1912.
16. Horner, J. M.: A Study of the Composition of Pineapple Plants at Various Stages of Growth as Influenced by Different Types of Fertilization. *A.H.P.C. Exp. Sta. Bul.* 13, 1930. (*Cited by Johnson.*)
17. Hume, H. H.: Pineapple Culture. IV. Handling the Crop. *Fla. Agr. Exp. Sta. Bul.* 84, 1906.
18. Johnson, M. O.: The Pineapple. *Paradise of the Pacific Press, First Edit.*, 1935.
19. Kelley, W. P.: Report of the Chemist. *Hawaii Agr. Exp. Sta. Rept.*, 1910.
20. Macmillan, H. E.: Tropical Planting and Gardening. *Macmillan & Co., London*, 1935.
21. Mann, C. W.: The Handling of Porto Rican Oranges, Grapefruit and Pineapples. *Bd. of Comm. of Agr. Insular Exp. Sta. Rio Piedras, Rio Piedras, Porto Rico*, 1914.
22. Henricksen, H. C.: Pineapples. *Rept. Porto Rico Agr. Exp. Sta.* for 1923.
23. Report on Experimental Consignments of Zanzibar Pineapples. *Experimental Consignments Rept.*, No. 7, *Empire Marketing Board*, 1928.
24. Spoon, W.: Enkele Bijzonderheden over de Koeling van proefpartijen Indisch Vrucht. *Ber. Hand. Mus. Kol. Inst. Amsterdam*, 47, 1929. (*Malayan Agr, Jour.* XVIII, 1930.)
25. Vosbury, E. D. & Winston, J. R.: Pineapple Culture in Florida. *U.S. Dept. Agr. Farmers' Bul.* 1237, 1921.
26. Wardlaw, C. W., Leonard, E. R. & Baker, R. E. D.: Observations on the Storage of Various Fruits and Vegetables. Part II. *Tropical Agriculture*, XI, 9, 1934.
27. Wilcox, E. V. & Hunn, C. J.: Cold Storage for Tropical Fruits. *Hawaii Agr. Exp. Sta. Press Bul.* 47, 1914.
28. Williams, W. J.: Cold Storage of Pineapple and Pineapple Juice. *Ice & Refrig.*, LXXXV, 1, 1933.

Pomegranate.

The pomegranate (*Punica granatum*), believed to be native to Persia, is commonly grown in India, Afghanistan, Persia, Arabia and the Mediterranean region; it is also grown to a small extent in America from the Southern United States to Chile and Argentina, reaching its greatest perfection in the more arid regions. In humid climates the fruit is inferior in quality. The pomegranate is prized, particularly in hot dry regions, for its refreshing sub-acid flavour (4).

After harvesting, the fruits, which should be clipped and not pulled, will keep in good condition and retain their flavour for several months if stored in a cool dry place. Hodgson (3) has pointed out that, because of their tendency to splitting, the fruits of most varieties must be picked before they are quite ripe; having reached a certain degree of maturity, however, fruits will continue to ripen in cold storage (temperature not specified), where they will keep in excellent condition for five to six months. Quality is said to be improved by cold storage, the flavour becoming richer and more vinous (3).

Grasovsky and Weitz (2) have reported on a small consignment of pomegranates shipped from Palestine to England in 1930, the voyage lasting 15 days; (presumably common storage was used). The fruits were wrapped in tissue paper and packed with wood-wool in half orange cases. This consignment was unsatisfactory on account of over-ripeness, bruising, insect injury and decay and poor packing.

A temperature of 34°-35°F., and a R.H. of approximately 80 per cent. has been recommended for the storage of this fruit.

As fruits ripen there is a gradual decrease in acidity and increase in sugar content; chemical studies indicate that colour is not a reliable index of maturity (1).

References.

1. Chace, E. M., Church, C. G. & Poore, H. D.: The Wonderful Variety of Pomegranate. *U.S. Dept. Agr. Circ.* 98, 1930.
2. Grasovsky, A. & Weitz, J.: Pomegranate Growing in Palestine. *Gov. Palestine, Dept. Agr. & For. Agr. Leaflet Ser. I V, Hort.*, 31, 1933.
3. Hodgson, R. W.: The Pomegranate. *Calif. Agr. Exp. Sta. Bul.* 276, 1917.
4. Popenoe, W.: Tropical and Sub-Tropical Fruits. *The Macmillan Coy., New York*, 1920.

Potato.

The Irish potato (*Solanum tuberosum*), in its original form a native of Chile and Peru, does not thrive well in moist tropical lowlands, but can be grown with a varying measure of success in other tropical and sub-tropical regions provided rainfall and temperature are not excessive.

Pre-Storage Factors and Harvesting.

Potatoes should be reasonably mature on harvesting, and should be dug and handled with care as this is the stage at which they are most susceptible to mechanical injury. It is an advantage if they can be allowed to remain in the ground for several hours after digging to permit the skin and dirt to dry thoroughly (29, 30); if high temperatures prevail, *i.e.*, above 80°F., exposure for about one hour should suffice. The sides of collecting baskets should be lined or padded. Immature tubers should be cured, *i.e.*, hardened and dried, after harvesting; this is hastened by thorough ventilation (29).

Where weather conditions during and immediately after harvesting are favourable to the growth of micro-organisms, infection of wounded tubers may take place: it follows that any procedure that reduces the number of injuries to tubers will increase the storage life of the crop (29).

Kimbrough (11, 12) records that applications of various fertilisers in field trials had no apparent influence on the subsequent keeping quality of Irish potatoes, although some variation was observed in the analyses of tubers from different plots. Tubers from less vigorous plants were characterised by a relatively low moisture and high starch content: differences observed at digging remained in evidence during the storage period (12).

Storage Conditions—General Consideration.

An extensive literature has accumulated on the subject of potato storage. Two objects must be kept in view, namely, preservation of the natural quality for table purposes and retention of vigour in stock intended for "seed" (23). The proportions of sugar and starch in the potato tuber are closely controlled by temperature: storage at 32°F. makes for the accumulation of sugar with the production of an undesirable sweetness (1, 26, 27); even at 36°F. a perceptible sweetness develops after several months in storage. Barker (2) has shown that when sugar concentrations are low the relative amounts of sucrose and hexose are also markedly affected by temperature.

During the storage life of potatoes an early, middle and late phase may be recognised. Weiss *et al.* (29) have pointed out that although tubers may be dry when first placed in storage, they are liable, under certain conditions, to undergo "sweating", *i.e.*, become covered with moisture.

"This may be due to the initially high rate of respiration and transpiration of freshly dug tubers continuing high for some time in storage, or it may arise during the storage term when, as a result of close piling in large masses, the removal of the heat and moisture of respiration is restricted and the atmosphere within the mass assumes a higher temperature than that of the storage room. The ascending current of warm air is cooled by contact with the air above the bin, with the result that moisture is deposited in the upper layers . . . sweating, particularly if it is continuous, is associated with early sprouting. Both sweating and premature sprouting are favourable to wound infection and rapid progress of decay. To prevent sweating it is necessary to prevent rise of temperature within the bin above that of the storage chamber."

The requirements during the early storage period are maintenance of dry stock and prevention of heating. Several investigators (30, 31, 34) call attention to the advantages which accrue from a preliminary curing period of 12-17 days, at a temperature in the neighbourhood of 60°F., prior to storage at a lower temperature.

During the middle storage period the tubers are dormant, their respiratory activity is low, a firm and tough skin has developed, and spouting is in abeyance. If proper storage conditions have been provided during the early period, so that the stock is dry and free from internal heat, the dormant state may be maintained for a considerable time at a temperature of 40°-45°F. Lower temperatures may also be used; ventilation requirements are not exacting during this period.

The third period is marked by the loss of the innate dormancy; thereafter, the prevention of sprouting depends on the application of an undesirably low temperature. The rate of respiration again increases, and tubers stored at 38°-40°F. tend to undergo a rise in temperature; this cannot be prevented in deep bins, 6 to 8 feet deep, but may be overcome by the use of small packages (crates or bags) stacked so as to permit of adequate air circulation. With the rise in temperature within the bin, sprouting is accelerated and condensation of moisture is likely to occur. Attempts to retard germination by lowering the temperature of the storage room at this time have the effect of increasing condensation or "sweating." These several changes favour the

progress of incipient decay, and the development of new infections through the sprouts. The prevention of decay during late storage is bound up with the suppression of germination: both are largely determined by proper handling during the early period (29).

Temperature and Humidity.

Both temperature and humidity factors are important in potato storage. The general conclusion to be drawn from earlier investigations is that favourable storage conditions are provided by a temperature in the neighbourhood of 40°F., with a relative humidity of 85-90 per cent. (9, 13, 14, 17, 18, 19, 20, 23, 24, 26, 27). Under these conditions spouting is delayed for 3-5 months and the subsequent growth of the buds is slow. The temperature range for inducing complete dormancy lies between 36° and 40°F. (24).

Recent investigations have shown that potatoes stored at 50° to 60°F. have the best flavour, texture and colour, when cooked; and because of the more complete formation of cork at high temperatures over wounded areas, shrinkage at 60°F. is actually less than at lower temperatures (8). The danger of excessive sprouting towards the end of the dormant period in storage can be avoided by a judicious lowering of the temperature to 40°-45°F. Storage at 40°F., however, should not be discounted, since at that temperature a very satisfactory control of rotting is obtained (24). For the manufacture of chip potatoes, storage at 60°F. gives the best results; potatoes stored at temperatures below 50°F. are liable to be unuseable in this way (25, 35). Sprouting takes place more quickly at the higher temperatures but this can be avoided by lowering the temperature to 40°F., or storing at 40° and removing to 60°F. two to three weeks before the stock is required. Potatoes that are undesirably sweet for table use will lose much of their sugar if held at 60°F. for two to three weeks; the recovery of normal flavour, however, is not quite complete (20).

In studies with new potatoes, Barker (3) has observed that although low temperature and high humidity retard the setting of the skin and the loss of the fresh appearance, a temperature of 41°F. is too low since it accentuates sweetening (21); storage at a higher temperature is therefore necessary.

When potatoes are stored in cellars, the initial humidity should be high to hasten wound healing and curtail water loss. Storage at a temperature of from 55° to 65°F. for 1 week after harvesting, with adequate ventilation provided, is considered by Werner (30, 31) to be optimal; after 7 or 10 days the temperature should be dropped as rapidly as possible to about 40°F. In discussing the question of bin or bulk storage as against bag or crate storage, Weiss *et al.* (29) consider that the former may be adopted where low storage temperatures, *e.g.* 30°-35°F. are employed, but that the latter, which permits of better ventilation, should be employed when the storage temperature is in the neighbourhood of 38°-40°-45°F. The construction of different types of storage pits and houses has been fully described by Stuart (23); in general a temperature of 36°-40°F. is considered suitable; quick cooling and the exclusion of light are important; adequate ventilation and humidity control are recommended.

Potatoes should not be stored in the same room with fruits, nuts, eggs, dairy products, &c., or tainting may result (20).

Seed Stock.

"Seed" stock, required for early planting, may be stored at about 40°F. immediately after harvesting. Stock required for late planting should be moved from 40°F. to about 38°F. after three to five months. It has been ascertained that at 36° to 38°F. potatoes will remain dormant indefinitely (23). Gardner (7) and Morris (15) have shown that storage at 35°-37°F. or 35°-40°F. gives adequate control of storage rots among seed potatoes; storage at 36°-40°F. for 15 days is efficacious in destroying the potato moth at all stages of its life history. Etheridge *et al.* (6), and other investigators, consider that seed stock, held at low temperatures for as long as 6 months, is not only not harmed by such treatment but actually gives a vigorous stand of plants.

The temperature at which "seed" potatoes are held prior to planting exercises a marked influence on the rapidity of germination, the stand of plants obtained, and the yield (16): tubers held at 40° and 50°F. for 2-3 weeks before planting germinated better and yielded young plants from 5-12 days earlier than did tubers which had been held at 32°F.; the vigour and rapidity of growth and subsequent yield confirmed the merit of storing at the higher temperatures. Cut seed potatoes, held for 10-20 days at 50°F. and a R.H. of 95 per cent. also give satisfactory results in field trials (33).

Ventilation and Gas-Storage.

The proper ventilation of potatoes in storage is important, the need for aeration being closely related to the storage temperature employed. At low temperatures potatoes may be stored in deep piles (*e.g.* 6 feet) at 40°F. for long periods; on the other hand, at temperatures above 45°F. deep piling must be avoided—at 50°-70°F. it should not exceed 3 feet—or special means of ventilation introduced (22). Potatoes stored under conditions of inadequate aeration quickly develop a type of physiological injury to which Bartholomew (4,5) has given the descriptive name of black-heart. Affected tubers may appear normal externally, but when cut open they show an area of dead, black tissue, occupying a considerable portion of the interior. In some instances a cavity lined with a thick layer of tough, necrosed black tissue may be observed. Black-heart, according to Bartholomew, is due to changes in the tissues caused by over-heating in an atmosphere insufficiently supplied with oxygen to meet the demands of rapidly respiring tubers; the

accumulation of CO_2 under these conditions is considered to play a less important part in the production of the symptoms observed. Black-heart may occur as a result of over-heating during transport or as a result of faulty storage conditions.

Stewart and Mix (22) have shown that black-heart can also be produced at quite low temperatures provided oxygen is excluded; the length of time required to produce pathological symptoms at different temperatures is largely a function of the time required to utilise the oxygen available under the storage conditions provided. They also state that black-heart may be expected to appear whenever the volume of air available to the tubers is less than that required for normal sprouting. Black-heart may sometimes occur in out-of-door pit storage; experience shows that aeration in unventilated small pits, however, is usually better than might be expected.

Some gas storage experiments have been described by Barker (3). Preliminary observations indicated that although the setting of the skins of new potatoes was successfully retarded by storage in an atmosphere containing 20 per cent. of carbon dioxide and 7.5 per cent. of oxygen at 41°F., the eating quality of the tubers was impaired by sweetening and defects in texture. The best results were obtained when tubers were stored at 45°F. in a gas mixture containing 5-10 per cent. carbon dioxide and 15-10 per cent. oxygen.

Freezing and Freezing Injury to "Seed" Potatoes.

Annual losses from freezing of potatoes in storage or transit may be very extensive (32). Critical studies of low temperature and freezing injury have therefore a special importance. The freezing point for potatoes, *i.e.*, the temperature at which ice crystals form within the tissues, is approximately 29°F. (28.5° to 29.5°F.), variations being due to individual and varietal differences, soil conditions and seasons.

The conditions under which potatoes may be subject to freezing injury have been investigated by Wright *et al* (32, 36). In general, two classes of frost-injured potatoes may be recognised: (i) those frozen solid and subject to collapse immediately on thawing; and (ii), those which only show evidence of injury on being cut open a few hours after being warmed; the first class—the result of freezing at very low temperatures or of prolonged exposure at higher freezing temperatures—is easily identified by the soft, wet condition that develops on thawing. The second type, which is not apparent on superficial examination, is due to exposure to temperatures just below the freezing point or to a very low temperature for a short time. On cutting open thawed tubers, various symptoms of freezing injury are apparent. Jones, Miller and Bailey (10) have described three types of necrosis, *viz.*: ring net and blotch. In the ring type only the vascular ring, situated near the surface, is discoloured (20); in the net type, threadlike areas radiating from the centre are discoloured; the third type is marked by irregular blotched areas. As a rule no further pathological changes take place after the injured tubers have thawed; in severe cases, however, the tubers soon begin to break down if kept warm.

Wright and Taylor (36) have summarised the information on freezing injury as follows: potatoes freeze more quickly when exposed to a rapidly diminishing temperature than when the temperature falls slowly; potatoes can be undercooled several degrees below their true freezing point and then warmed again above the freezing point without suffering from freezing injury, provided no ice formation takes place within the tissue; when undercooled, jarring resulting from rough handling or incidental to hauling, is liable to cause potatoes to freeze; after freezing commences it is progressive; the extent of injury caused within a given time appears to depend upon the surrounding temperature; immediately freezing takes place in undercooled tubers, the temperature rises to its true freezing point and remains there for a varying length of time, depending upon the surrounding temperature; varietal differences in susceptibility to freezing injury following undercooling have been observed.

Wright, Peacock and Lombard (37) have shown that the yield from "seed" potatoes which have been subjected to a short freezing treatment may be considerably decreased; affected tubers may show definite blackened areas in the flesh or no visible symptoms of freezing injury may be apparent. Such freezing injury may take place as a result of brief exposure to low temperatures during transport. In experiments in which "seed" potatoes were exposed for periods ranging from 2½ to 40 hours at controlled temperatures varying from −1° to −5°C., Wallace and Barker (28) have demonstrated a decreased yield—as determined by subsequent field trials—of about ten per cent. in the less severe treatments and of 25 per cent. in the most severe treatment (ten hours at −5°C.). Their observations suggest that, unless freezing is sufficiently severe to produce obvious external or internal symptoms of physiological injury, it is not possible to distinguish slightly injured "seed" which will inevitably give a decreased yield, from normal uninjured tubers.

References.

1. Appleman, C. O.: Changes in Irish Potatoes During Storage. *Maryland Agr. Exp. Sta. Bul.* 167, 1912.
2. Barker, J.: The Effect of Temperature on the Sucrose/Hexose Relation in Potatoes. *Dept. Sci. & Ind. Res. Ann. Rept. Food Invest. Bd. for* 1934. *H.M. Stationery Office*, 1935.
3. Barker, J.: The Storage of Vegetables. *Dept. Sci. & Ind. Res. Ann. Rept. Food Invest. Bd. for* 1935. *M.H. Stationery Office*, 1936.

4. Bartholomew, E. T.: Black Heart of Potatoes *Phytopath.* III, 1913.

5. Bartholomew, E. T.: A Pathological and Physiological Study of the Black Heart of Potato Tubers. *Centralb. Bakt.*, II, 43, 1915.

6. Etheridge, W. C., Helm, C. A., Stadler, L. J., Quinn, J. T., Miller, M. F. & Dudley, F. L.: Field Crop Experiments in Missouri 1923-24. *Missouri Sta. Bul.* 228, 1925; (*Exp. Sta. Rec.*, LIII, p. 431, 1925).

7. Gardner, J. S.: Some Observations on the Control of Rots Contracted by Seed Potatoes in Cold Storage. *Potato Assoc. Amer. Proc.*, X, 1923, (*Exp. Sta. Rec.*, LV, p. 750, 1926).

8. Higher Storage Temperature for Potatoes. *Ice & Refrig.* LXXXIV, 2, 1933. (*Int. Bul. Inf. Refrig.*, XIV, 1933.)

9. *Idaho Sta. Bul.* 164, 1929.

10. Jones, L. R., Miller, M. & Bailey, E.: Frost Necrosis of Potato Tubers. *Wis. Agr. Exp. Sta. Res. Bul.* 46, 1919.

11. Kimbrough, W. D.: Effect of Fertiliser on Quality of Vegetables. *Thirty-ninth Ann. Rept. Agr. Exp. Sta. Alabama Polytech. Inst. for year ending June 30th*, 1928.

12. Kimbrough, W. D.: Effect of Fertiliser on Yield and Quality of Irish Potatoes and Water Melons. *Fortieth Ann. Rept. Agr. Exp. Sta. Alabama Polytech. Inst. for year ending June, 30th*, 1929.

13. Kimbrough, W. D.: The Relation of Respiration to Storage and Transportation of Potatoes. *Potato Assoc. Amer. Proc.*, XI, 1924.

14. McLeod, D. J.: Relation of Humidity to Proper Potato Storage. *Ice & Refrig.* LXXV, 5, 1928. (*M. Bul. Inf. Refrig.*, X, p. 552, 1929.)

15. Morris, H. E.: Storage Dry Rot of Potatoes. *Montana Sta. Bul.* 183, 1926; (*Exp. Sta. Rec.*, LV, 1926).

16. Peacock, W. M. & Wright, R. C.: Influences of Different Storage Temperatures on Dormant Seed Potatoes. *Potato Assoc. Amer. Proc.*, XIV, 1926. (*Exp. Sta. Rec.*, LX, p. 331, 1929.)

17. Pennsylvania. Committee on Storage Investigations. *Potato Storage Investigations* 1924-25, *Canton, Pa.*, 1926.

18. Pinn, A. J.: Experiments in Cold Storage of Potatoes. *Agr. Gaz. New South Wales*, XXXII, 1921.

19. Pinn, A. J.: Cold Storage of Potatoes. *Agr. Gaz. New South Wales*, XXIX, 1928.

20. Refrigerating Data Book. *Publ. Amer. Soc. Refrig. Eng.*, *3rd Edit.*, 1936.

21. Smith, A. M.: *Scottish Jour. Agr.*, XVII, 1934.

22. Stewart, F. C. & Mix, A. J.: Black Heart and the Aeration of Potatoes in Storage. *New York Agr. Exp. Sta. Bul.* 436, 1917.

23. Stuart, W.: Potato Storage and Storage Houses *U.S. Dept. Agr. Farmers' Bul.* 847, 1927.

24. Stuart, W., Lombard, P. M. & Peacock, W. M.: Comparative Influence of Different Storage Temperatures on Weight Losses and Vitality of Seed Potatoes. *U.S. Dept. Agr. Tech. Bul.* 117, 1929.

25. Sweetman M. D.: The Relation of Storage Temperatures of Potatoes to their Culinary Quality. *Amer. Potato Jour.*, 8, p. 174, 1931.

26. Tserevitinow, F. & Spitsine, E.: The Influence of the Temperature of Storage of the Potato and its Chemical Composition. *Exp. Sta. for Fruits and Vegetalles, Inst. Nat. Econ., Moscow. Kholodilncie Dielo*, No. 9, 1926; (*M. Bul. Inf. Refrig.*, VIII, p. 761, 1927.)

27. Tserevitinow, F. & Spitsine, E.: Influence of Keeping Temperature of Potatoes on their Chemical Composition. *M. Bul. Inf. Refrig.—Rept. Fifth Int. Cong. Refrig. Rome*, 1928.

28. Wallace, E. R. & Barker, J.: The Effect of Freezing on the Yield of Seed Potatoes. *Dept. Sci. & Ind. Res. Ann. Rept. Food Invest. Bd.* for 1933. *H. M. Stationery Office*, 1934.

29. Weiss, F., Lauritzen, J. I. & Brierley, P.: Factors in the Inception and Development of Fusarium Rot in Stored Potatoes. *U.S. Dept. Agr. Tech. Bul.* 62, 1928.

30. Werner, H. O.: The Cause and Prevention of Mechanical Injuries to Potatoes. *Nebraska Sta. Bul.* 260, 1931. (*Exp. Sta. Rec.*, LXVI, 1932.)

31. Werner, H. O.: Storage Losses with Sound and Damaged Triumph Potatoes. *Proc. Amer. Soc. Hort. Sci.*, XXXII, p. 514, 1934.

32. Wright, R. C. & Diehl, H. C.: Freezing Injury to Potatoes. *U.S. Dept. Agr. Tech. Bul.* 27, 1927.

33. Wright, R. C. & Peacock, W. M.: The Storage of Cut Seed Potatoes. *Potato Assoc. Amer. Proc.*, 14, pp. 131-136, 1927; (*Exp. Sta. Rec.*, LX, p. 331, 1929.)

34. Wright, R. C. & Peacock, W. M.: The Storage of Potatoes immediately after Harvest. *Potato Assoc. Amer. Proc.*, 14, pp. 122-125, 1927; (*Exp. Sta. Rec.*, LX, p. 331, 1929.)

35. Wright, R. C., Peacock, W. M., Whiteman, T. M. & Whiteman, E. F.: The Cooking Quality, Palatability and Carbohydrate Composition of Potatoes as Infuenced by Storage Temperature. *U.S. Dept. Agr. Tech. Bul.* 507, 1936.

36. Wright, R. C. & Taylor, G. F.: Freezing Injury to Potatoes when Undercooled. *U.S. Dept. Agr. Bul.* 916, 1921.

37. Wright, R. C., Peacock, W. M. & Lombard, P. M.: Influence of Freezing of Seed Potatoes on Viability and Yield. *U.S. Dept. Agr. Tech. Bul.* 119, 1929.

Salsify.

For the storage of salsify or oyster plant (*Tragopogon porrifolius*), Rose *et al.* (1) recommend a temperature of 32°F. and a R.H. of 90 to 95 per cent.

Reference.

1. Rose, D. H., Wright, R. C. & Whiteman, T. M. The Commercial Storage of Fruits, Vegetables and Florists' Stocks. *U.S. Dept. Agr. Circ.* 278, 1933.

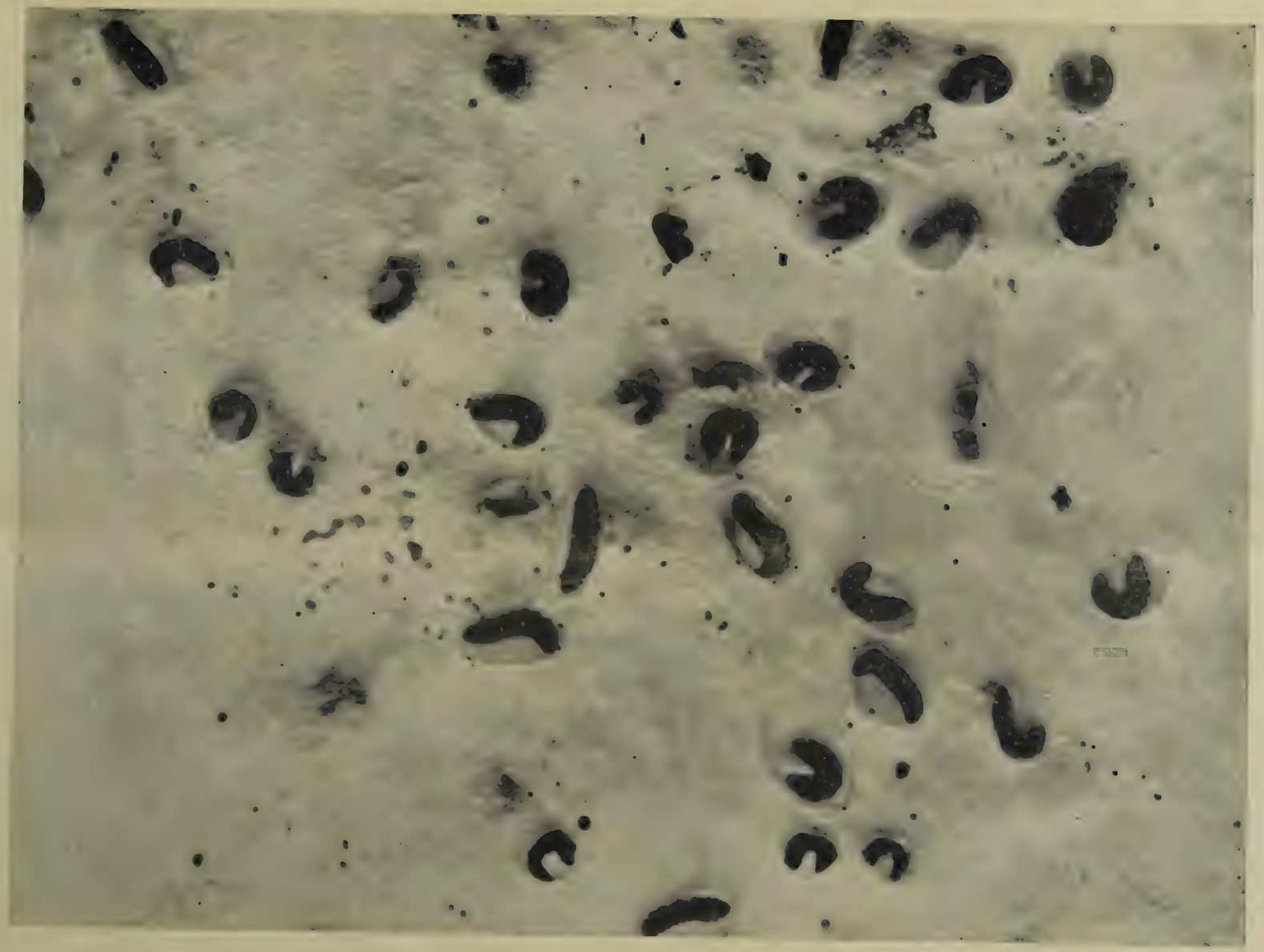


Photo: A. K. Briant.

FIG. 2.—Resting pink bollworm larvae in cotton wool between glass plates

A THEORY OF DIAPAUSE IN *Platyedra gossypiella* SAUND.

By F. A. Squire.
(*Agricultural Advisory Department.*)

The resting stage of the pink bollworm of cotton, on account of its great economic importance, has been closely studied in nearly all countries where cotton is grown as a commercial crop, and there has been a good deal of speculation as to the factors inducing long-cycle development. Most investigators are inclined to view it as either aestivation or hibernation. Thus Loftin, McKinney and Hanson (1) state that in Laguna, Mexico, the percentage of resting larvae rises with the onset of winter. The average frost date is 20th November. By that time short-cycle forms are exceptional. A small percentage, however, rest as early as August when the temperatures are still high and food is still abundant. These authors conclude therefore that the phenomenon is a " combination of aestivation (sic) and hibernation ".

Taylor (2) in Uganda clearly considers that the long-cycle is induced by aestival conditions. Ballou (3) in Egypt regarded it as hibernation but pointed out that in rare cases it may cover two winters and the intervening summer. Wolcott (4) in Puerto Rico states that the resting stage develops during the months January to April; so here again the idea of a seasonal phenomenon is implied. Gough (5) in Egypt is of opinion that " the hibernation of full-fed larvae is induced by the temperature of their surroundings at the time of their reaching maturity ". Taylor concludes from his observations in Uganda that " it is evident that the climatic factors associated collectively with the resting stage are long periods of complete drought, day temperatures exceeding 95°F . . . ." " The mere fact " he continues " that larvae do not normally rest in any part of Uganda shews at once that a rainfall of 40 to 60 inches distributed through most months of the year, a relatively high mean daily humidity (exceeding 50 per cent.) and a mean daily temperature in the neighbourhood of 70°F. with a maximum of 90°F. and a minimum of 50°F. together induce short-cycle development ".

A study of conditions in the eastern islands of the West Indies reveals the fact that this meteorological summary might well have been written of Nevis or Montserrat, or, making allowance for the porosity of the soil which discounts a higher rainfall, of St. Vincent. Yet in all these islands the long-cycle regularly appears. Furthermore, observations in the Lesser Antilles where the cotton crop is grown at different times of the year in the several islands, clearly demonstrate that the association of the resting stage with the onset of winter in some countries and with aestival conditions in others is purely accidental and that it really develops towards the end of the cotton crop at whatever time of the year this may take place. Thus in St. Vincent cotton is planted in September. In January the first resting larvae are found and the percentage rises through the dry months following, up to the end of April, when the close season starts. In Montserrat, on the other hand, cotton is planted in February and the long-cycle is evolved during the wet months from August to November. Barbados, Nevis, and St. Vincent plant in September; Montserrat and St. Kitts in the first quarter of the year. In every case the resting stage commences to manifest itself from about the fifth month of growth onwards.

It appears therefore that the resting stage has little to do with weather or season but is in some way connected with the age of the crop. With these considerations in mind, observations were directed to the influence of the quality of food on the life-cycle. It soon became apparent that larvae from green bolls never rest. In March 1937, several hundred bolls were collected from a heavily infested field in St. Vincent. Some, though full, were still green and contained only white seed, others contained black but not quite ripe seed and still others which had been open for some time contained ripe seeds, *i.e.*, seeds which if left any longer would have been naturally dispersed in a short time. These bolls were opened and the larvae removed and kept in separate glass jars with an adequate supply of the food on which they had been feeding. The results observed are set out in Table I.

Table I.

	White Seed.	Unripe Black Seed.	Ripe Seed.
Number pupated ...	60	43	35
Number resting ...	Nil	15	106

In April this test was repeated. Bolls of varying degrees of maturity were collected from badly infested fields at Villa in St. Vincent. These bolls were kept for seven to ten days when they were analysed, the pupae and larvae counted and the larvae put aside to see how many rested. The results are summarized in Table II.

During the same period 1,000 ripe dry bolls were collected from the same fields of which only 200 were examined. The results are presented in Table III.

Table II.

Remarks.	No. of Bolls.	No. of Pupae.	No. of Larvae.	Per centage resting
Collected 25th April. Green bolls. Some partly open, others about to open	55	57	46	5.9
17th April. Full bolls but not yet opening	57	58	54	9.8
15th April. Young bolls	100	34	15	8.2
15th April. Half grown bolls, some dry ...	37	31	24	18.0
22nd April. Green bolls of various sizes	70	40	54	1.1
Ditto.	60	37	63	3.0
Ditto.	60	70	19	1.1
16th April. Half full bolls	60	40	9	8.0
22nd April. Young bolls	60	90	13	0.9
	559	457	297	5.6 (av.%)

Table III.

No. of bolls.	No. of Pupae.	No. of Larvae.	Percentage resting.
200	4	250	92.5

From these tables it will readily be seen that it is mainly on ripe bolls that the resting stage is produced. Field observations indicate that the small percentage found on green seeds does not occur at all in nature, but is attributable to the fact that the bolls were kept in the laboratory for seven to ten days during which time the seeds ripened and dried somewhat. A good many of the seeds, even in the youngest bolls, had turned black by the time the examination was made.

At the same time several hundred infested flowers were collected from the same field. The larvae were successfully reared on the floral parts and in every case they pupated directly.

Further evidence was afforded by the examination of ochro pods, *Hibiscus esculentus* :—

Table IV.

Remarks.	No. of Pods.	No. of Pupae.	No. of Larvae.	Per centage resting.
15th April. Smooth variety. Dry pods	56	15	28	47.0
Same Green pods ...	10	—	12	—

Here again it will be seen that it is only ripe dry seed that gives rise to the long-cycle. To verify these results, a number of larvae of all instars were fed on green and ripe seed. The difference is set out in Table V :—

Table V.

	1st Instar.	2nd Instar.	3rd Instar.	4th Instar.	Percentage of survivors resting.
Ripe ...	165 all died.	51 all died.	40	86	40.0
Green ...	122	12	10	61	Nil.

Of the 3rd and 4th instar fed on ripe seed only 48 survived, in spite of the fact that the seeds were wetted several times to soften them. Of those fed on green seeds nearly all survived. The following instars were observed separately :—

2nd Instar.—21 fed on ripe seeds wetted towards the end, seven survived of which two pupated and five rested.

3rd Instar.—14 fed on ripe seed wetted towards the end, seven survived of which five pupated and two rested.

4th Instar.—81 fed on ripe seed wetted towards the end, 48 survived of which 29 pupated and 19 rested.

The seeds were wetted to prevent greater mortality. The larvae make very poor progress on hard dry food.

It is interesting to compare the conclusions arrived at by workers on the diapause of the Russian Meadow Moth, *Loxostege sticticalis L.* Steinberg and Kamensky (6) found that the diapause is due to peculiar nutritional conditions arising at certain times and not directly to winter conditions. Strelnikov's (7) experiments shew that in order to build up the protoplasm, 85 per cent. of water is required. If insufficient water is absorbed it is bound by the protoplasm. Rich food induced diapause by its greater tendency to bind the free water. Under natural conditions diapause is caused by dry and/or rich food. In the case of the pink bollworm it is only ripe seeds that are liable to be insufficiently moist, so that in this case the two factors operate together.

In the light of these facts, it is easy to understand the evolution of the resting stage with the increasing preponderance of ripe bolls towards the end of the season. In order to understand the development of the long-cycle, it is necessary to follow up the history of a typical infestation. This is graphically represented in Fig. 1. To sum up then it may be said that the field conditions inducing long-cycle development are (*a*) the increase in the ratio of ripe to green bolls, and (*b*) a sufficiently high incidence of the

A THEORY OF DIAPAUSE IN *Platyedra gossypiella* SAUND.

By F. A. Squire.
(*Agricultural Advisory Department.*)

The resting stage of the pink bollworm of cotton, on account of its great economic importance, has been closely studied in nearly all countries where cotton is grown as a commercial crop, and there has been a good deal of speculation as to the factors inducing long-cycle development. Most investigators are inclined to view it as either aestivation or hibernation. Thus Loftin, McKinney and Hanson (1) state that in Laguna, Mexico, the percentage of resting larvae rises with the onset of winter. The average frost date is 20th November. By that time short-cycle forms are exceptional. A small percentage, however, rest as early as August when the temperatures are still high and food is still abundant. These authors conclude therefore that the phenomenon is a " combination of aestivation (sic) and hibernation ".

Taylor (2) in Uganda clearly considers that the long-cycle is induced by aestival conditions. Ballou (3) in Egypt regarded it as hibernation but pointed out that in rare cases it may cover two winters and the intervening summer. Wolcott (4) in Puerto Rico states that the resting stage develops during the months January to April; so here again the idea of a seasonal phenomenon is implied. Gough (5) in Egypt is of opinion that " the hibernation of full-fed larvae is induced by the temperature of their surroundings at the time of their reaching maturity ". Taylor concludes from his observations in Uganda that " it is evident that the climatic factors associated collectively with the resting stage are long periods of complete drought, day temperatures exceeding 95°F . . . ." " The mere fact " he continues " that larvae do not normally rest in any part of Uganda shews at once that a rainfall of 40 to 60 inches distributed through most months of the year, a relatively high mean daily humidity (exceeding 50 per cent.) and a mean daily temperature in the neighbourhood of 70°F. with a maximum of 90°F. and a minimum of 50°F. together induce short-cycle development ".

A study of conditions in the eastern islands of the West Indies reveals the fact that this meteorological summary might well have been written of Nevis or Montserrat, or, making allowance for the porosity of the soil which discounts a higher rainfall, of St. Vincent. Yet in all these islands the long-cycle regularly appears. Furthermore, observations in the Lesser Antilles where the cotton crop is grown at different times of the year in the several islands, clearly demonstrate that the association of the resting stage with the onset of winter in some countries and with aestival conditions in others is purely accidental and that it really develops towards the end of the cotton crop at whatever time of the year this may take place. Thus in St. Vincent cotton is planted in September. In January the first resting larvae are found and the percentage rises through the dry months following, up to the end of April, when the close season starts. In Montserrat, on the other hand, cotton is planted in February and the long-cycle is evolved during the wet months from August to November. Barbados, Nevis, and St. Vincent plant in September; Montserrat and St. Kitts in the first quarter of the year. In every case the resting stage commences to manifest itself from about the fifth month of growth onwards.

It appears therefore that the resting stage has little to do with weather or season but is in some way connected with the age of the crop. With these considerations in mind, observations were directed to the influence of the quality of food on the life-cycle. It soon became apparent that larvae from green bolls never rest. In March 1937, several hundred bolls were collected from a heavily infested field in St. Vincent. Some, though full, were still green and contained only white seed, others contained black but not quite ripe seed and still others which had been open for some time contained ripe seeds, *i.e.*, seeds which if left any longer would have been naturally dispersed in a short time. These bolls were opened and the larvae removed and kept in separate glass jars with an adequate supply of the food on which they had been feeding. The results observed are set out in Table I.

Table I.

	White Seed.	Unripe Black Seed.	Ripe Seed.
Number pupated ...	60	43	35
Number resting ...	Nil	15	106

In April this test was repeated. Bolls of varying degrees of maturity were collected from badly infested fields at Villa in St. Vincent. These bolls were kept for seven to ten days when they were analysed, the pupae and larvae counted and the larvae put aside to see how many rested. The results are summarized in Table II.

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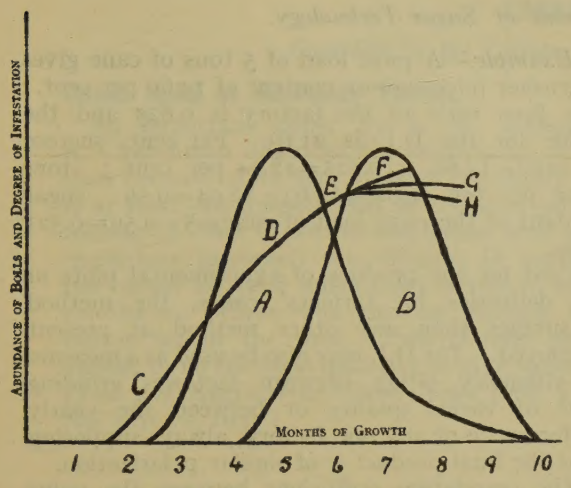

Fig. I.—Illustrating the History of a Typical Infestation of Pink Bollworm.

A.—Green Boll Phase. B.—Ripe Boll Phase. C.—Floral Infestation. D.—Infestation of Green Bolls. E.—Saturation Point of Infestation of Green Bolls. F.—Infestation of Ripe Bolls Resulting in Evolution of Resting Stage. G.—Infestation of Very Young Bolls of the Second Crop. H.—Infestation of Flowers of Second Crop.

pest to necessitate the infestation of ripe and ripening bolls which in the ordinary way are passed over the pest preferring younger bolls; hence the increasing number of larvae in picked cotton and resting larvae in the seeds as the season advances.

Correlated with the free water deficiency theory of diapause is the discovery by Townsend (8) that the addition of water to the tissues of hibernating larvae of the Codling moth *Cydia* (*Carpocapsa*) *pomonella* expedites emergence. Experiments in St. Vincent with 100 dormant larvae half treated and half as controls all placed in a thin layer of cotton wool between glass plates (Fig. 2) shew that this is likewise the case with the pink bollworm.

Table VI.

Treated 50 resting larvae the cotton wool around them being kept moist.			
in 2 days	9	had	pupated
in 6 ,,	19	,,	,,
in 9 ,,	30	,,	,,
in 13 ,,	32	,,	,,
in 20 ,,	48	,,	,,

The remaining two failed to pupate in spite of frequent applications of water. During this time none of the control larvae pupated. The experiment was repeated twice with similar results. Observations on seed-cotton kept in the laboratory in dry conditions shewed that emergency took place fairly regularly in spite of the lack of moisture. It may be concluded therefore that the addition of water to the tissues of the dormant larvae naturally or artificially through expediting emergence, is certainly not a *sine qua non* thereof. Furthermore there is always a small percentage of larvae that continue to rest in spite of the addition of water.

Summary of Conclusions.

1. The apparent hibernation or aestivation of the pink bollworm is really a case of diapause and is induced by dry and/or rich food towards the end of the crop irrespective of the time of the year at which this takes place.

2. The field conditions leading up to this position are (*a*) the increase in the ratio of ripe to green bolls, and (*b*) a sufficiently high incidence of the pest to necessitate the infestation of ripe and ripening bolls.

3. From observations on infested cotton bolls and ochroe pods, it appears that only those larvae which complete their larval development on ripening seeds are liable to go into the resting stage.

4. The addition of water to the tissues of resting larvae in most cases expedites emergence, but is not a *sine qua non* thereof and in a small percentage of cases fails to terminate the diapause.

References.

1. Loftin, U. C., McKinney, K. B., & Hansom, W. K. — Rep. on investigation of the pink bollworm of cotton in Mexico. *U.S.D.A. Bul.* No. 918, 1912.
2. Taylor, T. H. C.—Rep. on a year's investigation of *Platyedra gossypiella* in Uganda, 1936 (not published).
3. Ballou, H. A.—The pink bollworm in Egypt, 1916-17 Pt. 1. p. 29, *Cairo.*
4. Walcott, G. N.—*Rept. Seccion de Entomologica, Estacion. Exp. Insul. Puerto Rico.* 1932-33, pp.92-103, *San Juan. P.R.*
5. Gough, L.—The life-history of *Gelechia gossypiella* from the time of the cotton harvest to the time of sowing. *Tech. and Sci. Service. Bul.* No. 4, *Ministry of Agric. Egypt.*
6. Steinberg, D. M., and Kamensky, S. A.—Les prémisses oecologiques de la diapause de *Loxostege sticticalis L. Bull. biol.* 70, fasc. 2. pp.145-183. Paris 1936.
7. Strelnikov, I.—Wasserumsatz und diapause bei *Loxostege sticticalis L. C. R. Acad. Sci. U.S.S.R., N.S.*, 1936, 1. No. 6, pp. 367-371, Moscow, 1936.
8. Townsend, M.—The breaking up of hibernation in the Codling moth larva. *Ann. Ent. Soc. America* 19. 429. 1936.

INTERNATIONAL GRASSLAND CONGRESS.

The Volume of Abstracts of all papers presented at the Fourth International Grassland Congress held recently in Aberystwyth from July 15th to 17th has just been published in both English and German. This Volume brings together in abstract form the opinions and experiences of the chief grassland experts of the world. Subjects range from ecology of grassland and management of pastures to plant breeding and seed production, fertilizers and questions connected with animal nutrition. There are in all abstracts of 75 papers.

A report of the Congress will be issued in the autumn. The abstracts and complete Proceedings are available at £2 sterling, the Abstract Volume alone for 5s. Copies may be obtained from the Joint Secretaries, Fourth International Grassland Congress, Aberystwyth, Great Britain.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Heat Loss due to Methane, &c., in Waste Flue Gases. *R. von Mattekovich.*

Methane (CH_4) is a combustible gas forming at some point in the boiler passes. Its calorific value is 23,850 B.T.U., and assuming it to be present in the flue gases to the extent of 0.5 per cent. this is a heat loss of 198 B.T.U., or seven per cent. of the total available heat of 1 lb. of bagasse. It has usually been assumed that when no CO has been found in boiler tests by means of the Orsat apparatus there is no combustible gas present in the products of combustion, but this has been shown not to be the case. In addition to CO and CH_4, hydrogen, acetylene ethylene and ethane are also found in the waste gases, each of which possesses a high calorific value. Since these gases cannot be detected by the Orsat apparatus, equipment such as the Haldane apparatus is necessary for the investigation of such sources of heat loss.—(*Inter. Sugar Jl.*, Vol. XXXIX, No. 464, p. 323, 1937).

* * *

The Demerara Index: A simple Method of obtaining the Quality Ratio of Cane, and an Index of Factory Efficiency.

It has been noticed during the perusal of annual returns from several sugar factories that, if the figure for the percentage of sucrose in cane be added to the value for the tons of cane required to manufacture one ton of sugar, a fairly constant number (here called the "Demerara Index") is obtained.

Demerara Indices.

No.	1930.	1931.	1932.	1933.	1934.	1935.
1 ...	21.88	21.75	21.46	21.72	21.55	21.45
2 ...	22.83	24.38	23.81	23.47	24.95	23.49
3 ...	22.88	23.20	22.87	23.03	22.82	22.39
4 ...	21.73	21.84	21.88	21.74	21.71	21.70
5 ...	22.26	22.47	22.37	22.13	22.02	22.37
6 ...	21.92	22.07	21.75	21.72	21.69	21.60
7 ...	22.21	22.41	22.15	22.22	22.34	22.13
8 ...	22.93	22.29	22.50	22.19	22.25	22.20
9 ...	21.60	21.54	21.60	21.69	21.75	21.63
10 ...	22.02	21.92	21.73	21.83	21.46	21.47
11 ...	21.88	21.86	21.80	21.76	21.66	21.60
12 ...	22.08	22.42	22.10	22.09	22.10	22.05
13 ...	22.08	22.17	22.15	22.21	22.34	22.28
14 ...	21.82	22.16	22.03	21.99	21.88	21.80
15 ...	22.05	22.77	22.15	22.03	21.94	21.98

This circumstance suggests a simple method of obtaining a value for the quality ratio of parcels of cane passing through the mill. A sample of crusher juice from the parcel of cane is analysed, and the value for the sucrose content of the crusher juice multiplied by the Java ratio to give an expression for the sucrose percentage in cane which latter value is substracted from the Demerara Index for the particular factory to give a figure for the quality ratio of the cane.

Example.—A punt load of 5 tons of cane gives a crusher juice sucrose content of 14.60 per cent.; the Java ratio of the factory is 0.825 and the value for the D.I. is 21.63. Per cent. sucrose in cane $= 14.60 \times 0.825 = 12.04$ per cent.; tons cane per ton sugar $= 21.63 - 12.04 = 9.59$; sugar content of the punt load of cane $= 5 \div 9.59 = 0.521$ tons.

Used for the produce of experimental plots or for deliveries for farmers' canes, the method is simpler than any other method at present employed. The D.I. may also be used as a measure of efficiency either between factories grinding cane of varied quality or between the yearly performance of any one factory, always supposing that the final product is of similar polarization.

The correlation coefficient between the value of the D.I. and the overall recovery for 15 British Guiana factories for a period of 6 years is: $r = -0.9797$; and given the value for the Index (K) the overall recovery can be calculated with considerable accuracy by means of the regression equation:—

$$\text{Overall recovery} = 212.86 - 6.05K.$$

The corresponding correlation coefficient for eight Trinidad factories during the period 1934-35 is: $r = -0.9685$; while that for 17 Natal factories during the same period is: $r = -0.9721$.

The D.I. is not absolutely constant for any one factory but varies slightly with alterations in the sucrose content of the cane, the polarization of the sugar manufactured and the overall recovery, chiefly with the two latter. Thus any alteration in plant or process leading to a greater efficiency of the factory would be followed by a reduction in the value of the index.

Apart, however, from such slight variations as may be due to alterations in the polarization of sugar or factory efficiency, the index is to all intents and purposes a fixed value, and affords not only a ready means for determining the quality ratio of different lots of cane but is also a useful check on each week's calculations.—(*Inter. Sugar Journal*, Vol. XXXIX, No. 463, 1937, pp. 281-82.)

* * *

A Record Cane.

A stool of sugar cane which Hawaiian agriculturists believe represents a record growth in American cane farming has been produced on the plantation of the Kekaha Sugar Company, Ltd., Kauai Island. It contains 360 stalks of small barrel cane, stands 30 feet high, and weighs two tons. It is estimated that it contains 400 pounds of sugar. The stool is two year old cane of the variety Co. 290, originating from a seedling developed at the experiment station of the Hawaiian Sugar Planters' Association. Hawaii, however, is not the original home of the variety, which was first developed at the Coimbatore cane breeding station in India.—(*Facts About Sugar*, Vol. XXXII, No. 7, p. 266, 1937.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Cacao Shell as Accessory Fodder.

An important paper by A. W. Knapp and A. Churchman describes the importance of cacao shell because of its high vitamin D potency which is at least one-quarter that of cod-liver oil. The feeding of cows in winter and under stall-feeding conditions increased the vitamin D content of the butter fat (and milk) from winter to summer conditions. There was also an increase in the butter fat in the milk. Two pounds per day appear to be the ideal quantity to give to cattle.—(*Ind. and Engineering Chem. News Edit.* Vol. 15, No. 4, p. 75, 1937.)

* * *

Grass-Drying Plant.

It appears amply proved that, cut at the proper time and dried, grass forms a more palatable and nutritious food than many types that have long been on the market. Imperial Chemical Industries, Ltd., have been among the pioneers in this work. More than 25 plants are now working in England, one farmer producing sweet-smelling, green, and nutritious dried material at £4 a ton, which compares very favourably with artificial food at £7 a ton. The grass contains about 16 per cent. protein equivalent, 62 per cent. of starch equivalent, 9 per cent. of mineral matter, and is rich in carotene. One type of plant is a rotary oil-burning type, and another a coke-burning plant in which the grass is dried on trays. (*Ind. and Eng. Chem. News Edit.* Vol. 15, No. 4, p. 75, 1937.)

* * *

Physiology of Indian Crop Plants.

For some time past, the staff of the Institute of Agricultural Research of the Benares Hindu University has been engaged, under the leadership of Professor B. N. Singh, in detailed and comparative studies of the physiology of Indian crop plants. A considerable number of publications on this subject has now been issued, mainly in the *Proceedings of the Indian Academy of Sciences*, and good progress has evidently been made in a highly interesting and important field of work. The most extensive work completed is that dealing with photosynthesis under different conditions of light, temperature and carbon dioxide supply. Since a large part of previous research on this subject has been carried out in temperate climates, it will be obvious that detailed studies of tropical plants are likely to be of considerable value. One striking result of this work is that tropical plants are found to have a higher light requirement in photosynthesis than similar species grown under temperate climatic conditions. Another especially interesting problem under investigation is that of the differences in respiration rate found to exist in plants differing in their duration of life. Short-lived plants are apparently characterised by a low respiration rate, which also falls off very rapidly as the age of the plant increases. Long-lived plants, on the other hand, not only have a high respiration rate but also are able to maintain this higher rate throughout life. Other subjects under investigation by comparative methods include the water requirements of seeds possessing different structural and biochemical properties, and the effects on plant growth of irradiating seeds with X-rays.—(*Nature*, Vol. CXXXVIII, No. 3480, p. 70, 1936.)

* * *

Effect of Oxidizing Agents on Crop Production.

Professor V. Subrahmanyan, C. R. Harihara Iyer and R. Rajagopalan, of the Indian Institute of Science, Bangalore, have directed attention to the possibilities of increasing crop production through judicious applications of chemical oxidizers, and have outlined the attendant chemical and biological changes. All crops showed increase in the yield on both unmanured and manured soils. The oxidizing agents differed in efficiency, potassium permanganate usually being more active than either hydrogen peroxide or ferric oxide. Permanganate gave the best results when applied as a basal dressing, while manganese dioxide was most efficient as a top dressing. The crops also varied in their response to different oxidizers. Ammonia production in the soil was increased, and the oxidation of organic matter facilitated, but the biological changes consequent on the application of oxidizers were not pronounced. With permanganate there was an initial depression in the number of bacteria followed by a rapid rise after the fourth day. Soluble manganese salts applied to soil pass into an insoluble form and oxidation or organic matter occurs with the production of carbon dioxide, particularly on non-sterile soils. There is some evidence that biological activity is stimulated, resulting in greater production of carbon dioxide and, increased plant assimilation. Manganese dioxide and permanganate gave the best results, manganous sulphate followed next in order, while manganous carbonate was not much superior to untreated control. Pretreatment with lime was found to depress the yield, at any rate in the case of the eight varieties of tomatoes that were tried. In none of the cases was there any evidence of increased intake of manganese. The foregoing and other observations would suggest that although certain inorganic compounds may produce profound physiological effects in culture solutions, through purely ionic action, they act in a different way in the soil, this being particularly true of manganese salts, which are rendered insoluble in the soil.—(*Nature*, Vol. CXXXIX, No. 3518, p. 595, 1937.)

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.):—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
29th July	6	8¼	10	4¼
5th August	6	7½	10	4½
12th August	6	8¼	10	5¼
19th August	6	6¾	10	3¼
26th August	6	3¾	10	0
2nd September	6	4¼	10	1½
9th September	6	7½	10	4½
(*10th September*, 1936)	4	5¼	8	3

The market after a quiet and inactive period has been showing a decidedly easier tendency originating in New York where the market has been nervous and unsettled. Sentiment has been affected by the weakness of other commodities but more particularly by the circulation of reports that the U.S.A. had not yet ratified the agreement. In some quarters it is not certain whether the world agreement would come into effect but this has not been given serious attention in authoritative circles.

* * *

COPRA.—Trading conditions have been dull but values have held steady. West Indian f.m.s. is quoted at £16 7*s.* 6*d.*

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:—

	American Mid.	*Egyptian F.G.F. Sakel.*
30th July	6.12	9.05
6th August	6.20	9.48
13th August	5.93	9.28
20th August	5.78	8.27
27th August	5.63	8.18
3rd September	5.56	—
10th September	5.56	—
(*11th September*, 1936)	6.99	10.74

The official announcement of the U.S.A. Department of Agriculture estimating this season's cotton crop at 15,593,000 bales brought a shock to the raw cotton market which experienced a fall in values. The estimate was nearly half a million bales larger than traders expected. Although there is still a critical period of weather to pass through, it is believed that there will be plentiful supplies of raw cotton and it is not likely that prices will move on to a higher level. On the other hand it is possible that legislation may be passed in U.S.A. which will prevent prices from falling below ten cents a pound. In which case the market will probably become rather steadier. Demand for Sea Island has been small with prices ranging for small lots at 21*d.* to 22*d.* a pound.

COCOA.—The past month was a very quiet period for the cocoa market, many manufacturers preferring to await the usual period of heavier offerings from Bahia and Accra, but it is now expected that consumers generally will enter the market in an important way. The most active grinding season in the chocolate industry commences in the early fall, therefore, the next few weeks should find some important transactions taking place. New crop Accra is quoted at 39*s.* c.i.f. and locally the nominal price of Plantation Cocoa is $10.75 per fanega.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	Pence per lb.
28th July	8 13-16
4th August	8 7-8
11th August	8 13-16
18th August	8 13-16
25th August	8 7-8
1st September	8 7-8
8th September	9 1-8
(*9th September*, 1936)	7 5-8

The market has generally been quiet with prices fluctuating within narrow limits. Some disappointment was caused by the *American Questionnaire* figures which revealed that American consumption for the month of July was 43,650 tons as against an estimate of 47,000 tons. Total consumption in U.S.A. for the first seven months, however, amounted to 355,747 tons as compared with 331,950 for the same period last year.

* * *

COFFEE.—Demand has generally been slow except for Blue Mountain Jamaicas which sold up to 219*s.* for first size. Bold size London cleaned Costa Rica sold at from 54*s.* to 61*s.* 6*d.* Superior Santos 52*s.* 6*d.*; No. 7 Rio 42*s.*

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BANANAS.—There has been a steady business with prices for Jamaicas unchanged at £19 5*s.* per ton delivered London or £19 nearest station Provinces. Brazilians are quoted at £15 delivered London and £16 delivered Provinces.

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LIME PRODUCTS.—*Lime Oil.*—Handpressed is slow of sale and valued at 35*s.* to 37*s.* 6*d.* per lb. *ex* wharf London. Distilled is held for 25*s.* spot but forward sales are possible at lower rates according to position and quantity. *Lime Juice.*—The demand for Concentrated appears to be satisfied and Raw is quiet and unchanged at 1*s.* 10*d.* to 2*s.* 3*d.* per gallon.—(*West India Committee Circular* 12th August.)